MACHINERY

September, 1911

THE PROCESS OF MANUFACTURING PERMANENT MAGNETS*

By F. B. HAYS†

PERMANENT magnets are used on magnetos, tools, slot-machines, toys, voltmeters, ammeters, speedometers, telephones, wattmeters, ignition devices, recording instruments, compasses, controlling devices, physical instruments, and switches. The magnets used on these devices are of various shapes and sizes, the illustration, Fig. 1, representing the most common forms in use at the present time.

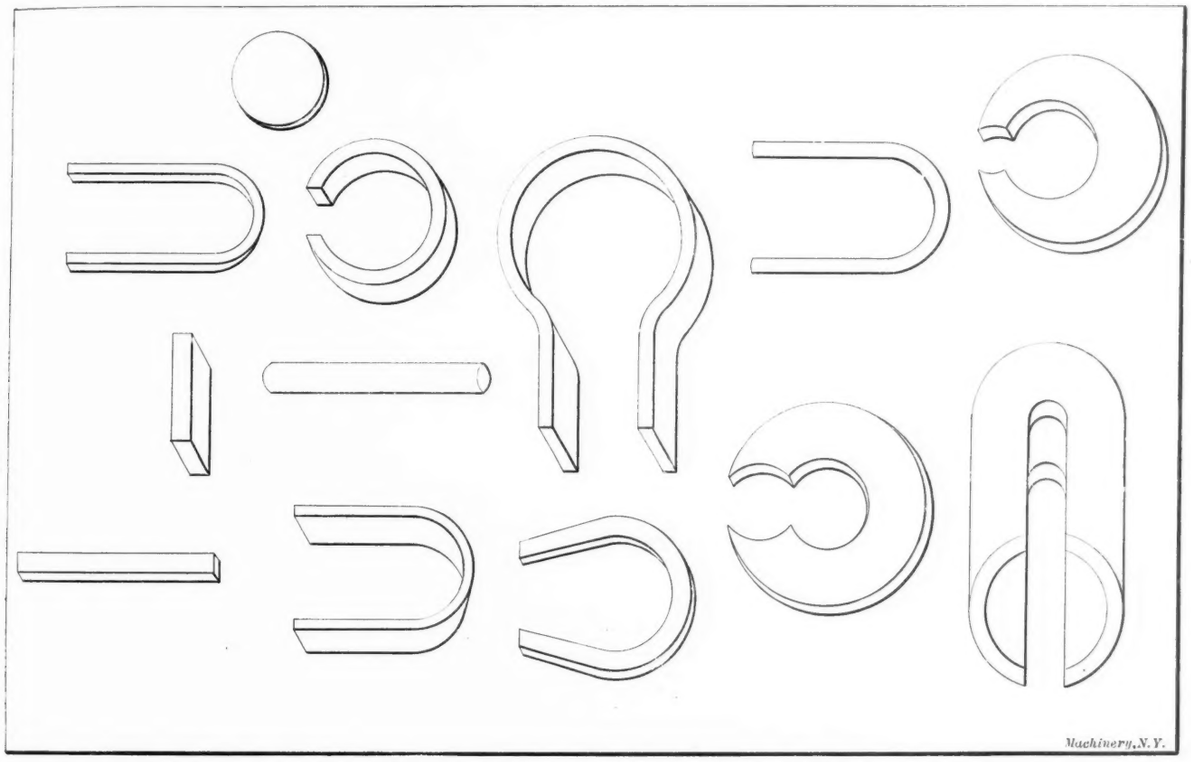


Fig. 1. A Collection of Various Types and Shapes of Permanent Magnets

The extensive use of permanent magnets, together with scientific methods of manufacturing them, has come about only in recent years. Ten years ago the production of permanent magnets was a branch of manufacturing of very little consequence, while today it is one of the important phases of the steel-working industry. Every plant making permanent magnets has its own process of manufacture, but the underlying and fundamental principles for the production of successful magnets are the same in all. A summary of these methods is given in this article.

Steel Used for Making the Magnets

Permanent magnets are made from alloy steels. The composition of these steels is governed to a large extent by the various purposes for which the magnets are to be used. For instance, telephone magnets are made from 50- to 60-point carbon steel containing a high manganese content. Where a stronger magnet is required, as for magnetos, a 50- to 60-point carbon steel with a 3 to 7 per cent tungsten content is used.

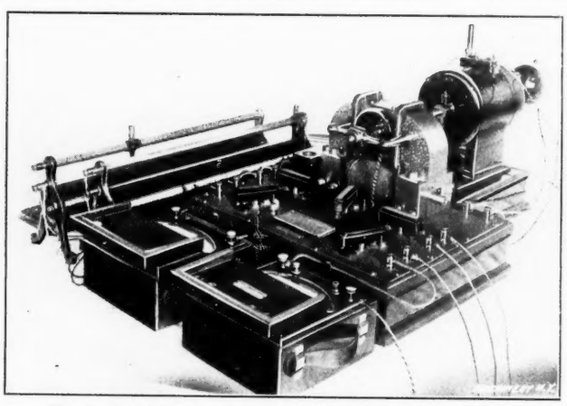


Fig. 2. Esterline Permeameter used for Testing Magnet Steel

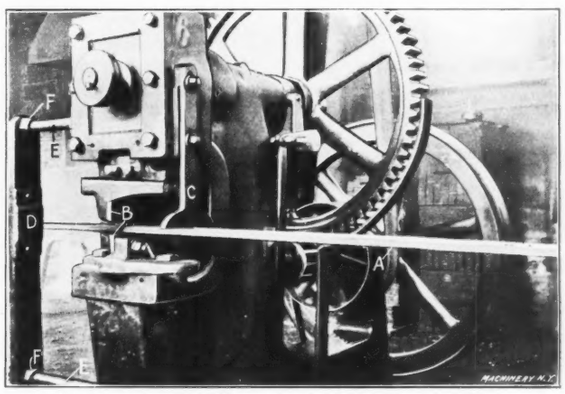


Fig. 3. Shearing Magnet Bars to the Required Lengths

Magnet steel is hard and tough before hardening, and its physical properties closely resemble those of low carbon tool steel. In several plants the scrap from the magnet department is used for lathe and shaper tools in the machine shop. After

* For additional information on this and kindred subjects previously published in MACHINERY, see: "The Operation and Manufacture of Magnetos—1 and 2," October and November, 1910, engineering edition.

† Address: 2225 Central Ave., Indianapolis, Ind.

hardening (chilling), the steel becomes as hard and nearly as brittle as glass. Magnet steel is rolled into bars and sheets of any desired size. Bar magnets such as are used on watt-meters and most magnetos are made from bars, while plate

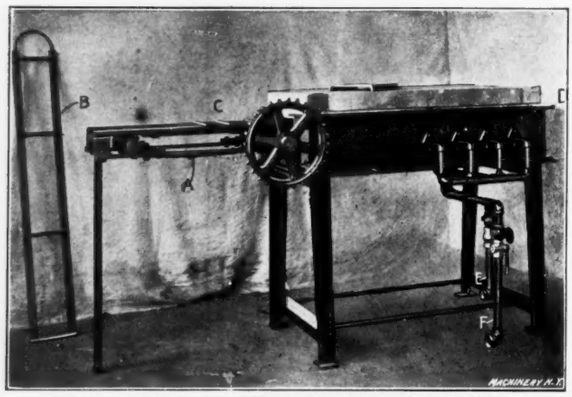


Fig. 4. Gas Furnace for Heating Bar Magnets for Bending

magnets such as those in telephone receivers and on some types of magnetos are made from sheets. The principal requisites of a good magnet steel are: uniformity of composition, freedom from blow-holes and seams, high magnetic qualities, retentivity, and freedom from cracks and blisters after treating.

Synopsis of the Methods of Making Magnets

The process of making permanent bar magnets may be divided into five distinctive steps, as follows: (1) Testing the steel; (2) cutting the bars to proper lengths; (3) heating and forging; (4) heating and hardening; (5) grinding and magnetizing. For plate magnets, the process is shorter: (1) Testing the steel; (2) punching the plates from the sheet metal; (3) grinding and magnetizing.

Testing the Steel

Magnet steel is usually tested both at the steel mill and at the plant where it is used, to determine the proper "heats", and the magnetic qualities of the steel. Several methods are employed to determine this information, the most efficient of which is the following: Test bars and plates of magnet steel, as well as magnet forgings, which have been treated at different heats are tested for strength, permeability, and retentivity by means of a direct-reading permeameter. The results of these tests show the best temperatures for treating the steel, and also furnish complete data regarding its magnetic qualities. This method is used in the large steel mills and also in most modern magnet manufacturing shops. A direct-reading permeameter which is used for testing the magnet steel bars is shown in Fig. 2. This instrument is made by the Esterline Co., Lafayette, Ind.

Cutting Magnet Bars to Required Lengths

The bars of magnet steel are obtained of the proper width and thickness, and then are sheared to the short lengths required for the magnets. The shears used for this purpose must be of massive construction, low geared, and provided with a heavy flywheel to overcome the sudden resistance offered by the hard-steel bars. The shaft driving the moving head must be adequately large or it will be twisted off when the shear blade strikes a hard spot in the steel, which frequently happens.

Some form of stop must be provided to accurately gage the length to which the bars are cut off. This stop must be strong and rigid and provided with some means of adjustment in order that it may be varied to suit the required length of the bars to be cut. The stop is usually placed on the opposite side from that at which the bar is fed, so that the operator may quickly push the bar through the jaws of the shear until its movement is arrested by one end of the bar butting against the stop.

The illustration, Fig. 3, shows a shear used for cutting the bars to the length required for the magnet. *A* is the bar of magnet steel, *B* the shearing blades, *C* a guide bar, to prevent the bar from tilting when it is being sheared, and *D* a stop for regulating the length of the piece being sheared. The stop *D* is adjusted along the threaded studs *E*, and when in the desired position is locked by the lock-nuts *F*.

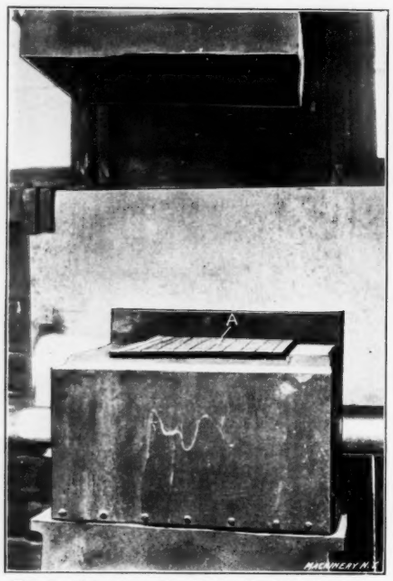


Fig. 5. Coke Furnace for Heating Bar Magnets for Bending—Bar Magnets shown at A

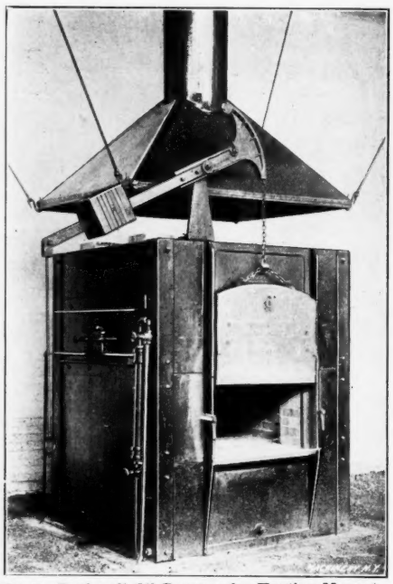


Fig. 6. Rockwell Oil Furnace for Heating Magnets before or after Bending

Fig. 7. Forming Odd-shaped Magnets by Hand

Forging

Practically all forms of bar magnets require one or more forging operations, to give them the proper shape. Forging operations on magnets are often termed "heating and

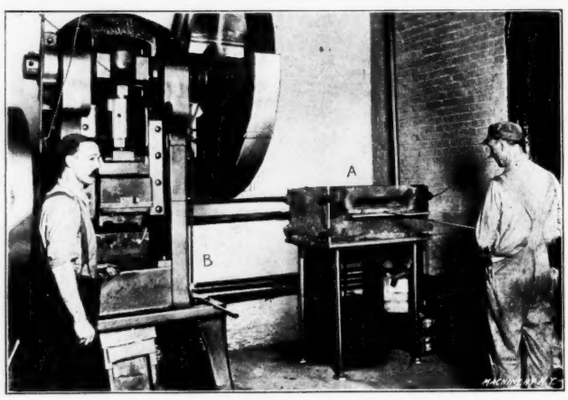


Fig. 8. Heating and Bending Magnet Forgings in the Sangamo Electric Co.'s Plant

bending", or "heating and forming", as the short bars (cut to the proper length by the shear) are heated and then bent to the required shapes. The bars are heated to from 1472 to 1652 degrees F. (according to predetermined temperature tests) in coke, oil, or gas furnaces made especially for this work. The illustrations Figs. 4, 5 and 6 and Fig. 8 at *A* show the four types of furnaces used. The heating tempera-

Fig. 9. Grinding Magnet Forgings

ture is regulated by electric pyrometers, as shown in Fig. 10. Coke furnaces are rapidly being superseded by oil and gas furnaces, as the latter can be more accurately regulated and produce better results.

The most recent development in this line is a furnace made by the American Gas Furnace Co., shown in Fig. 4. This furnace is equipped with a power-driven endless chain *A* upon

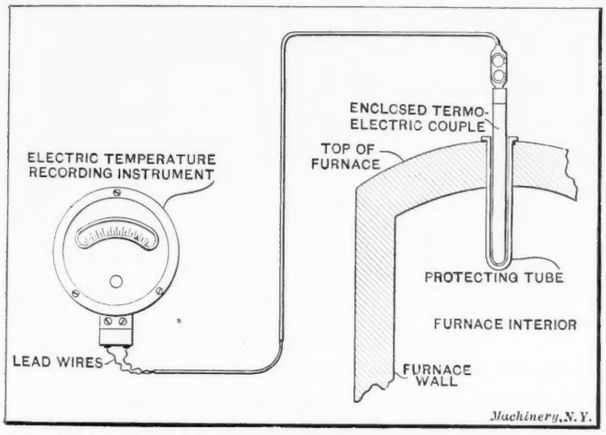


Fig. 10. Showing Application of an Electric Pyrometer to Magnet Heating Furnace

which is placed the carrier *B* loaded with the short magnet bars. The carrier moves slowly from left to right, the cold bars entering at *C*, being heated to the required temperature and discharged at *D*, at the rate of about six bars a minute. *E* is the gas inlet and *F* the air-blast inlet.

After heating, the bars are placed one at a time in some

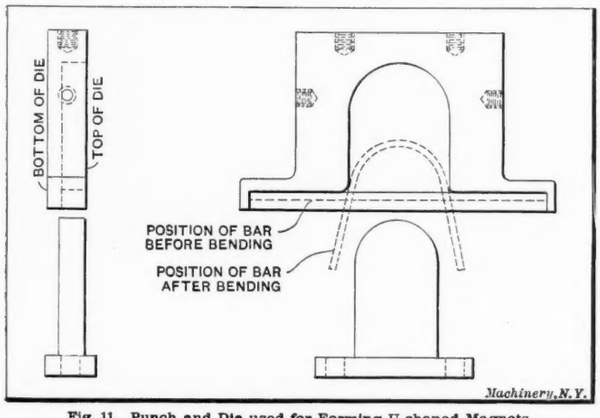


Fig. 11. Punch and Die used for Forming U-shaped Magnets in a Bulldozer

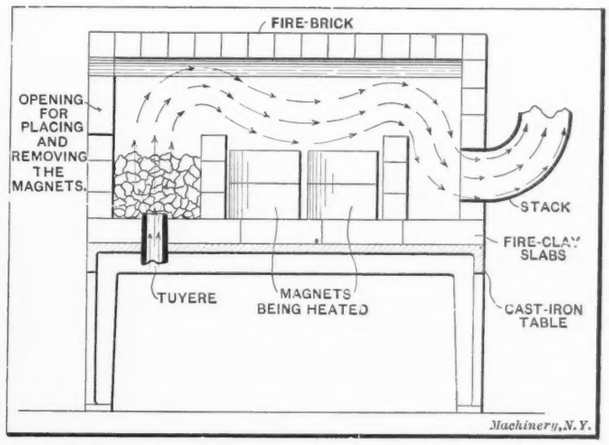


Fig. 12. Section of Coke Furnace for Heating Magnets previous to Hardening

form of power press, usually a very powerful and massive bulldozer or vertical press, as shown at *B*, Fig. 8. These machines are equipped with special dies (those for forming a U-shaped magnet in a bulldozer being shown in Fig. 11), which bend the bar to the correct shape. Simple magnets such as those of the horseshoe type require only one bending operation, whereas more complicated shapes require two or three

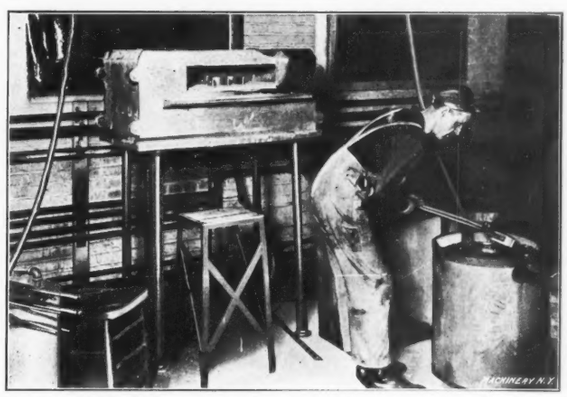


Fig. 13. Hardening Magnet Forgings in the Sangamo Electric Co.'s Plant

bending operations. Extremely irregular shapes which are not used in great quantity are bent by hand as shown in Fig. 7. This machine consists of a cast-iron die around which a steel roller is revolved by means of a lever to which the roller is pinned. One end of the hot bar is fastened to the die by a clamping device, so that the bar is held between the roller and the die. The lever is pulled around the die by the oper-

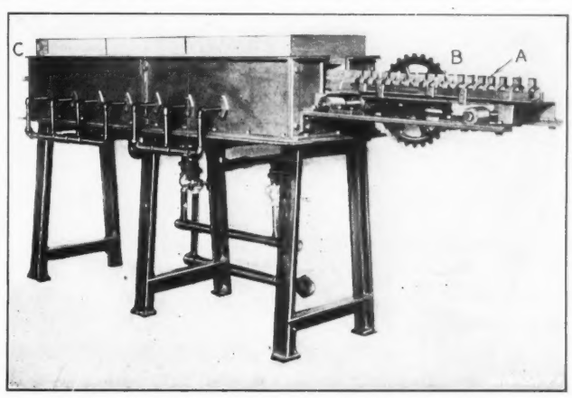


Fig. 14. A Gas Furnace for Hardening Magnets, equipped with a Conveyor

ator, causing the roller to press the heated bar against the die, and thus bending the bar to the desired shape.

Hardening

The forged magnet bars are now allowed to cool slowly in order to prevent crystallization. They are then ground on disk grinders or emery wheels to the proper lengths, as shown

in Fig. 9, and drilled or machined if so required by the specifications. After this they are placed in the hardening furnace, and brought to a temperature of from 1500 to 1600 degrees F. (as determined by previous tests). The temperature must be very accurately regulated, as a variation of only a few degrees is likely to injure the steel.

Coke, oil and gas furnaces are used as shown in Figs. 12, 13, and 14. Oil and gas furnaces give the best results, but are more costly and more expensive to operate than coke furnaces. The difficulties experienced with coke furnaces are due to the impurities in the coke, such as sulphur and silicon, being absorbed by the steel at the high temperature maintained. However, the fault is almost entirely overcome in a furnace constructed as shown in Fig. 12.

Fig. 14 shows a gas furnace similar to the one described for heating magnet bars for bending (Fig. 4). The magnet forgings *A* enter the furnace at *B* and are discharged at *C* at the rate of about four a minute. The magnet forgings shown in this illustration are for use in electric meters.

When the magnet forgings reach the required temperature they are removed from the hardening furnace and plunged into cold running water or brine, where they are allowed to

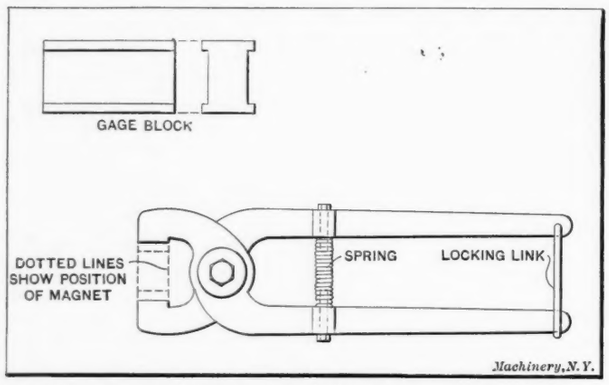


Fig. 15. Tongs and Gage Block for Holding Magnets while Hardening to prevent them from Springing out of Shape

remain until cold; they are then removed and piled up ready for grinding and magnetizing. When magnets of very accurate dimensions are required, such as those used on magnetos, the forgings are placed in special tongs with gage-blocks between them, as shown in Fig. 15, to prevent them from warping while cooling. A typical group of tongs for handling heated magnets is shown in Fig. 17. Magnet forgings of complicated shape are frequently annealed before hardening, in order to insure uniform heating.

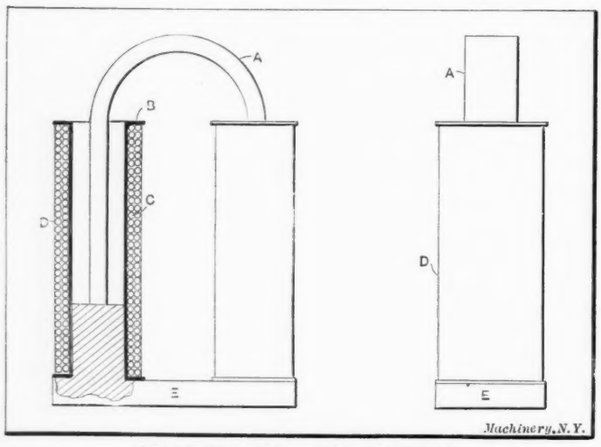


Fig. 16. Magnetizing a U-shaped Magnet

Grinding and Magnetizing

After being removed from the cooling bath, the forgings are ground to the specified dimensions and all scale and rough edges removed. They are then ready for magnetizing.

Magnetizing is accomplished by means of electro-magnets, solenoids, or a combination of the two. One of the most efficient devices for this purpose is shown in Fig. 16, in which *A* is the magnet being magnetized, *B* the shell of the solenoid, *C* the winding of the solenoid, *D* the insulating covering, and *E* the malleable iron electro-magnetic field piece. While the magnet is being magnetized, the current is rapidly interrupted and the magnet hammered with a rawhide mallet to cause the magnetic molecules to properly adjust themselves. From ten

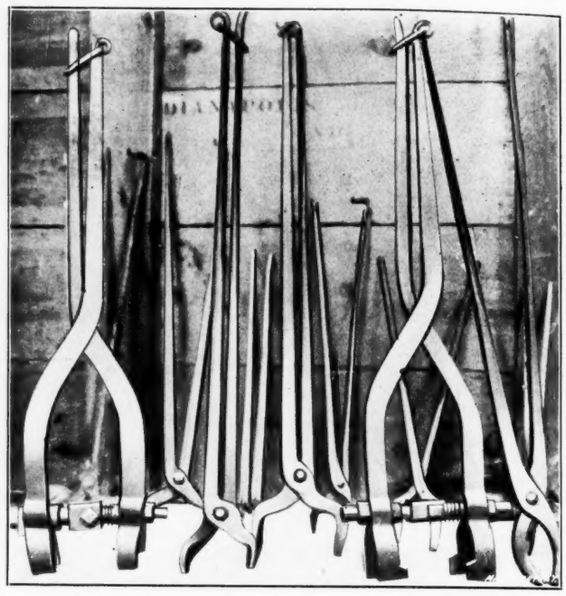


Fig. 17. A Group of Tongs for Handling Heated Magnets

to twenty seconds is usually required for each magnet. This is the last operation required in making permanent magnets. After magnetizing they are ready for use and will retain their magnetism for years under ordinary conditions.

Plate Magnets

Plate magnets are stamped out of sheet magnet steel 1/16 inch to 5/32 inch thick, by means of ordinary punch presses equipped with hardened steel punches and dies. The process

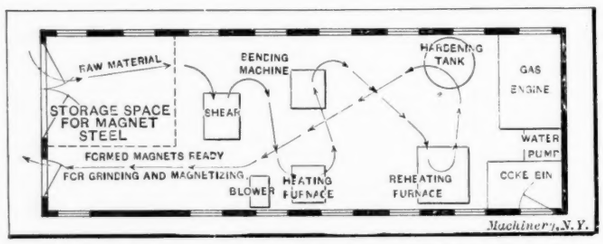


Fig. 18. Plan of Magnet Forming Department of Hercules Electric Co. Arrows indicate Movement of Stock

is practically the same as that used for making any form of flat stamping. The stampings require no grinding, drilling or machining before hardening. The method of hardening is similar to that used for other forms of magnets, except that special care must be observed to prevent warping, and to keep the hardening heat from being blanketed by accumulation of scale on the surface. The means used for grinding and magnetizing are similar to those used for bar magnets.

Conclusion

The manufacture of permanent magnets, although a comparatively new industry, has reached a place of considerable importance both from a monetary and scientific standpoint. Its rapid growth may be attributed to the extensive use of this type of magnet in electrical measuring instruments, magnetos, telephones, and recording instruments. The scientific production methods employed are due largely to the constant demand of magneto manufacturers for powerful magnets that will retain their magnetism for an indefinite period under all sorts of adverse conditions, and which will at the same time be absolutely accurate in size and shape. Taken as a whole, few branches of industry represent a more interesting study from a chemical, mechanical, and electrical standpoint than the manufacture of permanent magnets.

GAS ENGINE PISTON RINGS

By S. H. SWEET*

Designers of gas engines usually have certain forms of construction which they use in preference to others, but it is a good idea to know of the different forms in use, how they stand up, their good and bad points, the cost of manufacture, and how easily assembled and disassembled. Herewith are shown a number of wrist pins for gas engine pistons, taken from the writer's note-book, and some comments are made on the different designs. Of course the forms shown may be more or less familiar to many of the readers of MACHINERY, but some of them may be new or present ideas that will be of sufficient interest and value to find a place in their data- or note-book.

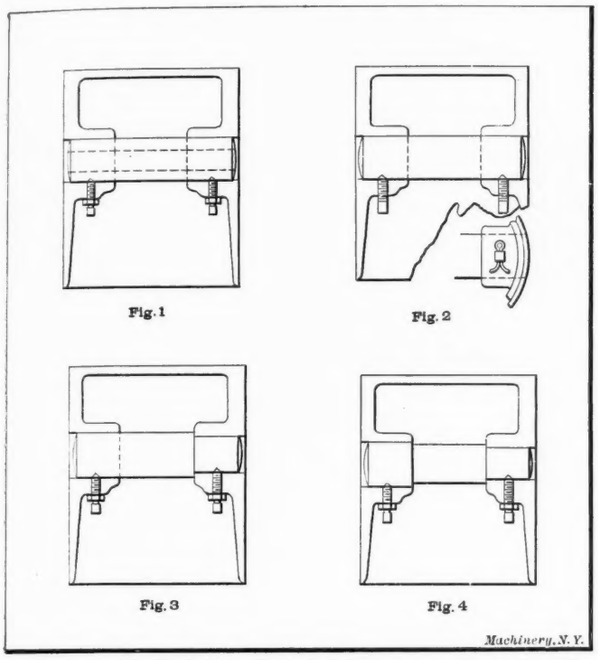


Fig. 1. Straight Pin held by Nut-locked Set-screws. Fig. 2. Same Pin with Set-screws locked by Cotters. Fig. 3. Two-stepped Pin. Fig. 4. Three-stepped Pin.

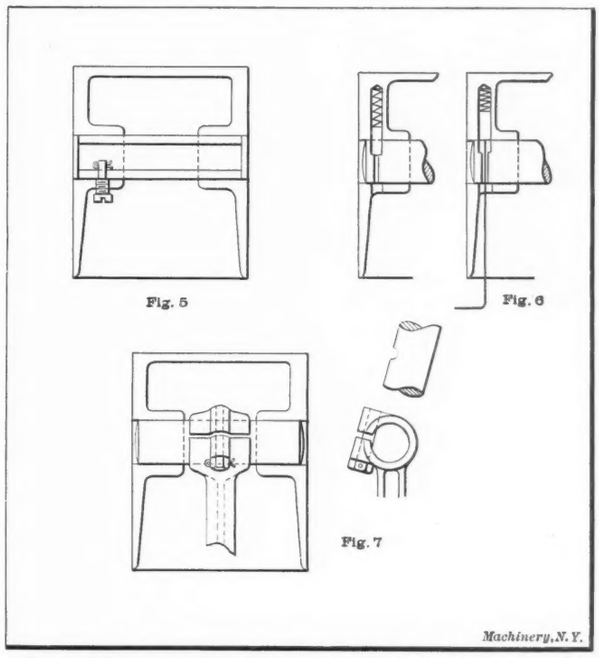


Fig. 5. Hollow Pin held by Projecting Reduced End of Set-screw. Fig. 6. Spring-pin Method of holding Wrist-pin. Fig. 7. Pin held by Screw in End of Connecting-rod

The wrist-pin shown in Fig. 1 is a straight pin which is held from end movement and from turning by set-screws with lock-nuts. The pins are spotted for the point of the set-screw, so that the latter will not form a burr which might cause trouble in removing the pin. The pins are made either solid or hollow as desired. When made hollow, a few holes drilled through the center connecting with an oil groove, form a good means of lubricating the wrist pin bearing at the piston end of the connecting-rod. The one shown in the illustration is probably the simplest and least expensive construction.

Fig. 2 shows the same construction as Fig. 1, with the exception that the set-screws are locked by cotter-pins instead of lock-nuts; the cotter-pins strike the wall of the piston and prevent the screw from turning. In some cases one set-screw is used instead of two. With a straight pin it is necessary to drive it in its full length, unless two different sizes of reamers are used, making one end a driving fit, and the other a sliding or running fit. However, if the wear on the central

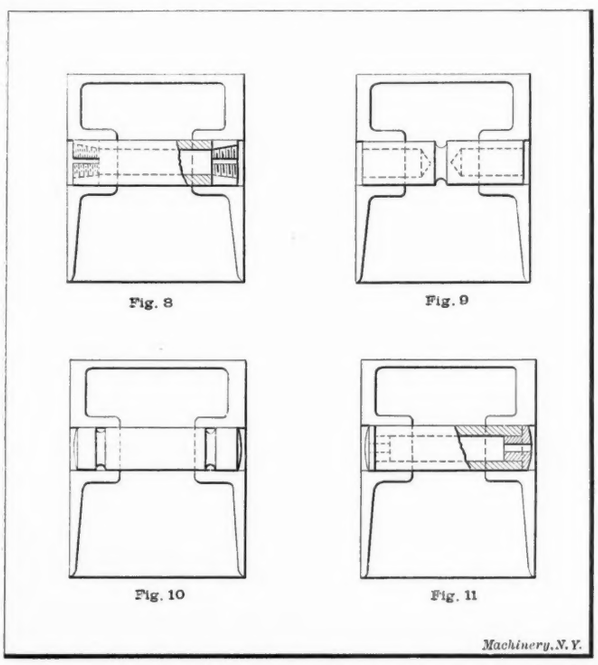


Fig. 8. Hollow Pin held by Expanding Plugs. Fig. 9. Pin with Circular Retaining Groove. Fig. 10. Circular Grooves in End of Pin. Fig. 11. Bronze-ended Pin

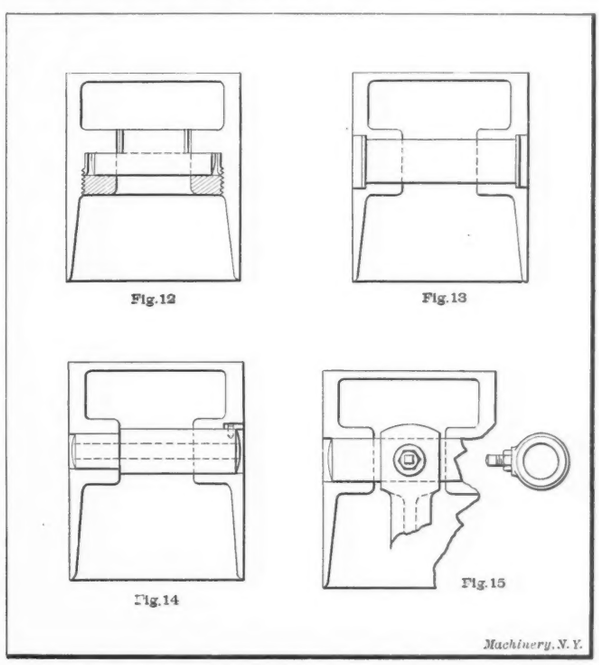


Fig. 12. Nut Method of securing Pin. Fig. 13. Pin with End Bosses. Fig. 14. Two-step Pin with Drive-fit End and Key. Fig. 15. Pin Held by Set-screw in End of Piston-rod

* Address: 1544 Park Ave., Bridgeport, Conn.

portion of the wrist-pin bearing forms a burr, it makes the removal of the pin difficult.

Fig. 3 shows a pin turned smaller on one end and held in the same way as that in Fig. 1. This pin can move in only one direction and only one set-screw is necessary. This construction costs more than the first, but the pin is more easily removed.

A three-step pin is shown in Fig. 4, and is held in the same manner as the one in Fig. 1. It is very easily assembled and removed, and it is only necessary to drive it the length of one of the piston bosses. While it is an expensive construction on account of the necessity for turning three sizes on a pin and requiring two sizes of reamers in the piston, this is compensated for by the fact that it can be turned down when worn without disturbing the ends which fit the piston.

In Fig. 5 is shown a hollow, straight pin kept from turning by a screw reduced on one end. The reduced part fits into a hole drilled in the wrist pin and the inner end is drilled to receive a cotter-pin to prevent it from backing out.

A pin held by a small plunger or spring pin is represented in Fig. 6, where the construction may be readily understood. When assemblying, the spring and plunger are put in place and the wrist pin pushed in until the plunger drops into the hole that is drilled in the wrist pin to receive it. This both locks the pin from end movement and turning. To remove the wrist-pin, a wire is inserted through a hole in the boss and the plunger pushed up clear of the wrist-pin; then by tapping the end of the latter it may be made to move sufficiently to prevent the plunger from dropping back. The wire is then removed and the wrist-pin driven out.

Fig. 7 shows the wrist-pin held by a screw in the end of the connecting-rod, the screw fitting into a groove milled in the side of the wrist-pin. This differs from the previously mentioned wrist-pins, for it is free to turn in the piston bosses and is held in the rod end, thereby giving more bearing surface.

The method of holding by splitting the pin and internally threading the ends is shown in Fig. 8. The pin is held by screwing in taper plugs which spread the ends, making a tight fit in the bosses. The objection to this plan is that the plugs are liable to work loose and score the cylinder walls.

In Fig. 9 a screw in the end of a connecting-rod fits in a groove turned in the center of the wrist-pin as shown. This construction is similar to that of Fig. 7. The wrist-pin is free to turn in the bosses and also in the rod end, giving a very good bearing surface, but at the same time the pin is materially weakened by the circular groove.

A wrist-pin similar to that just described is shown in Fig. 10, only it is stronger. Instead of a central groove there is one at each end of the pin, though one would be sufficient; the set-screws prevent end movement.

Fig. 11 shows a wrist-pin with soft bronze ends which has free rotary and endwise play in both the rod and piston bosses. The bronze ends prevent scoring the cylinder walls, if the end of the wrist-pin should rub against them.

A wrist-pin that is flattened at each end and is held in place by a threaded ring or nut is shown in Fig. 12. It will be noticed that neither the wrist-pin nor nut can turn unless the connecting-rod turns also. In assemblying, the nut is slipped over the rod, the pin is inserted in the bearing and the rod is used to tighten up the nut.

A wrist-pin that is made straight and is free to turn in the rod end and bosses is represented by Fig. 13. It is kept in place by a ring which also acts as a packing ring.

A wrist-pin used by a prominent designer is shown in Fig. 14. The stepped end is a driving fit in the piston boss, and a pin used in the opposite end prevents turning.

Fig. 15 shows a straight pin held by a set-screw in the rod end.

* * *

The firm of Krupp, in Essen, Germany, this year celebrates its hundredth anniversary. The firm was established in 1811, and for fifteen years only six persons were employed. Now the total number of employes is 70,000.

GRINDING HARDENED GEARS

By E. H. PRATT*

The subject of grinding hardened gears for automobile transmissions and similar purposes has been given much time and thought in the attempt to overcome the errors which creep in during the hardening process. In most cases these gears are made of special alloy steels which require very careful heat treatment, and if precautions are taken, there will be very little shrinkage and consequently less warping. In most cases a few degrees variation in the temperature of the ovens will cause warping—sometimes to a very marked degree. In the case under discussion, the gears are made from high-grade chrome-vanadium steel which requires twelve hours at 1,600 degrees F. to properly carbonize, and a reheating to 1,300 degrees F. for hardening. The latest improved electric pyrometer is used for testing the heat of the ovens. It was found that a variation of 50 degrees F. would change the shape of the gears; it is a very difficult matter to hold the heat of an oven for twelve hours within such a range.

From the difficulties thus experienced in tempering, it became necessary to devise some method of grinding the gears that would overcome the hardening errors, for the inspection department demanded gears within a 0.001-inch limit on the pitch line; that is, the pitch circle could not be eccentric by more than 0.001 inch. This is, of course, a very small margin, but having advertised a noiseless transmission it was necessary to hold to this limit in order to produce gears that would run close and smooth enough to be practically noiseless.

Several grinding chucks were used with but little success, and eventually it became necessary to devise a special chuck; the one to be described in this article is the outcome. In grinding gears, the gear is gripped concentric with the pitch circle, and when in that position, the hub is ground out so that the pitch circle will have no eccentricity. Of course the warping in the gear will have changed the pitch line from a true circle, which makes it necessary, in devising a chuck to grip the gear on the pitch circle, to equalize the variation caused by hardening, by placing a suitable bearing on each tooth of the gear.

Fig. 1 shows two typical automobile transmission gears, made of steel, hardened and ground in the hub, with the teeth

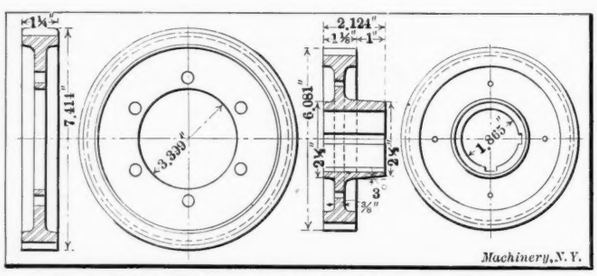


Fig. 1. Typical Hardened-steel Automobile Transmission Gears

lapped together. These gears are of a 6-8 diametral pitch and it was found that a 9/32-inch pin, when placed between two teeth, would bear on both sides at the pitch line. Taper pins *A*, such as shown in detail in the upper left-hand corner of Fig. 2, were formed, the lower side of the piece being made with a 9/32-inch diameter in order to fit in the teeth, as just mentioned. One such tapered piece was required for each tooth of the gear, being held in alignment in the proper place in the chuck by a hoop spring *B*, and circumferentially spaced by a disk *C* which provides clearance for these pieces. Outside of these pieces is an annular ring *D* with an inside taper corresponding to that of the taper pieces *A*. Outside of that, again, is another annular ring *E* also with a taper as indicated. These several rings are contained in a rigid cast-iron body *F*, which is made strong enough to withstand the severe strains due to the large number of taper surfaces used on the inner members. Inside this body *F* behind the tapered annular rings is a screw-adjusting plate *G*, threaded into the body

*Address: 1026 Washtenaw St., Lansing, Mich.

F with a 29-degree Acme thread. This body *F* is, in turn, attached to the chuck plate *H*, screwed onto the head of the grinder. A rod *I* passes through the hollow spindle of the grinder, and on the inner end has a head *J* with inwardly projecting pins engaging recesses in the face of the screw-adjusting plate *G*. On the outer end of rod *I* is a handwheel *K;* by turning this, the screw-adjusting plate may be moved backward or forward as desired. By moving the screw-adjusting plate forward, the taper strips *A* will be forced radially inward, gripping the gear on the pitch line and holding it accurately for the grinding operation. A spring *L* keeps the projecting pins on the rod *I* always in contact with the screw-adjusting plate.

To prevent emery from working into the threads of the screw adjusting plate, a felt washer *M*, is introduced as shown. Although it is impossible to prevent emery dust from working its way into the moving parts of the chuck, it was found that this felt washer was very effective.

The making of the screw-adjusting plate presents some interesting features. It is a steel forging, hardened and ground, and was first roughed out to within 1/16 inch of its finished size, then thoroughly annealed, and finally finished to size, threaded, drilled and hardened. Now a forging of this shape will always warp more or less in hardening, and this one proved no exception. As it was important to have the face absolutely true with regard to the thread on account of the bearing surfaces presented to the ends of taper pins, it became necessary to grind the piece, for it was badly warped. The

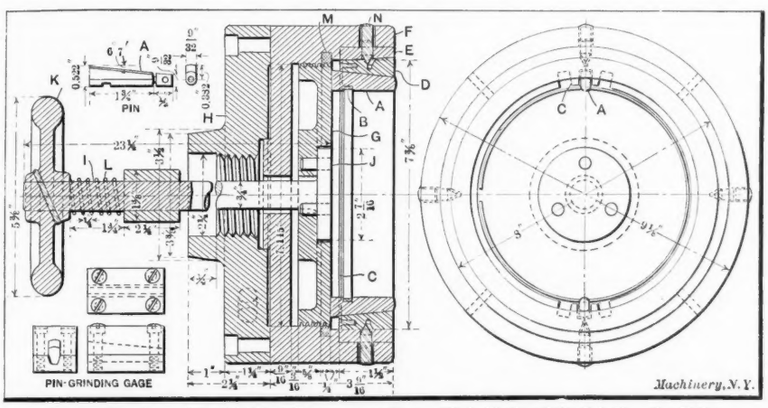


Fig. 2. Chuck used for Holding Gears correctly on Pitch Circle while Grinding the Hubs

thread was ground by setting up in an engine lathe in the usual manner and grinding the thread with an electric center-grinder. The chuck body was then threaded to fit this piece nicely.

The making of the taper pins *A*, shown in the detailed illustration in the upper left-hand corner of Fig. 2, is also interesting. The pins were centered on both ends and turned and milled to the proper size for grinding. Then about ½ inch

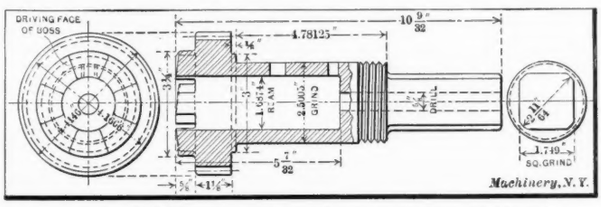


Fig. 3. Typical Transmission Drive Sleeve ground on Outside only

from the smaller end, the pin was cut nearly in two, and the small end had a transverse hole formed in it by which the pin was revolved on centers while grinding the 9/32-inch diameter; the larger diameter of the taper was also ground on these centers. As all pins had to be made exactly the same size in regard to both sides, a small gage was made, which is illustrated in the lower left-hand corner of the engraving. As will be seen, this gage represents a gear tooth and a section of the gear chuck circle. The pins are ground on the taper until they project about 1/64 inch beyond the gage, when they are ground on the end to bring them flush.

The annular chuck rings *D* and *E* are made of steel, hardened and ground inside, and are made of different sizes to suit the various gears; as shown, the chuck is arranged to hold the smaller gear illustrated in Fig. 1. When it becomes necessary to change these rings, the ring *D* is first removed

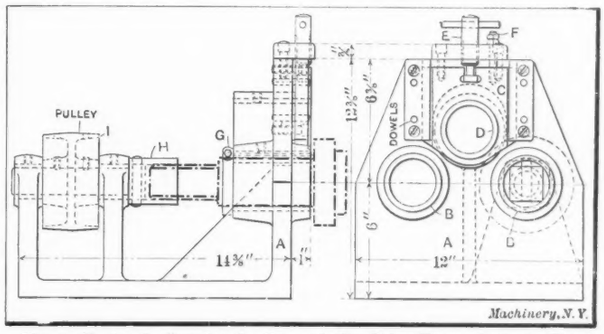


Fig. 4. Device for Lapping the Transmission Drive Sleeve shown in Fig. 3

by taking out the headless set-screw *N;* after this ring is removed, ring *E* will slip out.

The clamping device operated by the handwheel *K* would seem to give but little leverage, but it has enough to hold the gear firmly without springing it out of shape, and by the use of so many pins the bearing area is increased to such an extent that but slight pressure is required.

The chuck-plate *H* attached to the grinder spindle is ground in place in order to insure an accurate attachment of the chuck. The gears ground in this chuck are of various sizes and styles ranging from countershaft gears having 1⅞-inch holes, to main-shaft gears with 3½-inch holes; the main drive sleeve shown in Fig. 3 is ground on the outside only. These gears are not all ground on the same machine, two different chucks being used. For a smaller plant, however, one chuck should be ample to handle all the gears.

It was, of course, impossible to produce perfect gears from those sprung in hardening to the exent of from 0.003 to 0.008 inch, but after grinding, the variations were found to be evenly distributed, so that with the majority of them a short run on the lapping fixture was all that was necessary. Fig. 4 shows the fixture for lapping the drive sleeves, one of which is shown in Fig. 3. This jig is designed to lap three sleeves at a time. Bosses on the main casting *A* are bored out to receive bronze bushings *B* which fit the ground part of the drive sleeve, as indicated in the illustration. A vertically adjustable member *C*, operating in V-grooves, holds a third bushing *D* in which an intermediate gear can be placed and adjusted to give the required contact by means of the top adjusting screw *E*. Lock screw *F* may be set to give the same adjustment for each set of gears. The driven gear of the train is held in position by a collar *G*. The squared end of the drive sleeve is fitted to a corresponding coupling *H*, driven from the pulley *I*, which supplies power for the lapping process.

The fixture for lapping the other gears is similar to the one used for the drive sleeves, only as these gears have no ground external surface they are held on pins set in the face of the supporting casting, which is similar to the casting *A* just described. The upper one of the gears is adjustable in a manner similar to that in the last fixture, but the driven gear is on a pin which extends through the face of the main part of the fixture and has a pulley attached on the inner end by which the train of gears is driven. Adjustment is made as before through the upper vertical slide. After a few minutes lapping with emery and oil, the gears will be found to run smoothly and quietly, and will readily pass the closest inspection. With this chuck and fixture large numbers of gears pass through the shop and form what is probably the most quiet transmission construction that is known to the automobile trade.

DROP-FORGE DIE-SINKING—3

By CHESTER L. LUCAS* and J. W. JOHNSON†

In the first two articles of this series, the principles of making drop-forge dies were treated upon, covering all of the main operations of sinking the impressions in the dies. There are, however, many special operations that must be employed at times to correctly shape the impressions, and these are fully as essential to good die-sinking as are the rudiments of the trade. Space will not permit us to describe all the special operations in detail, but we can at least touch upon some of the most necessary of these operations, selecting at the same time the most interesting ones and those that are apt to be used in making the average line of drop-forging dies.

Cherrying

In making the impression in a drop-forging die for producing forgings for valve stems or other forms in which each

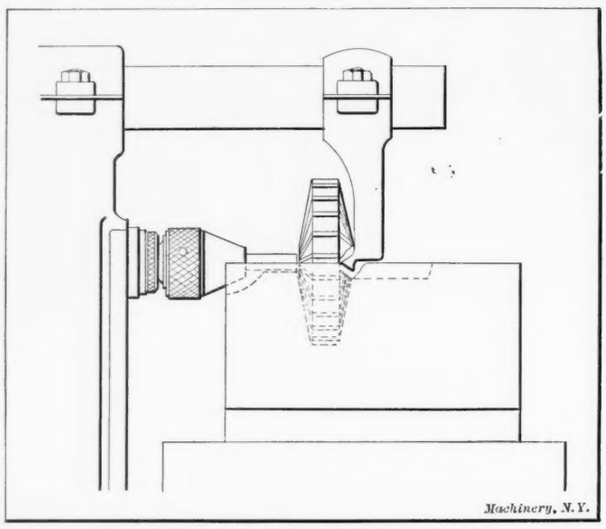


Fig. 32. Cherrying a Die on the Milling Machine

die will have at least one-half of its impression of the cylindrical shape, it is obvious that some means must be provided to sink a cutter into the die block to exactly one-half of its depth. There are several different methods of reaching this end, one of which is to use a special milling fixture in which the cutter is supported on a very short arbor and rotated by means of a raw hide pinion that meshes between the teeth of the cutter, this pinion being driven by the spindle of the

Fig. 33. Collection of Cherries used in Die-sinking

milling machine. Of course, the bulk of the steel in the impression is roughed out in the ordinary way before the special attachment and the finishing cutter are put into use.

Another method of sinking the cutter to one-half its depth is by the use of the method called "cherrying." Cherrying and cherries are terms somewhat unfamiliar to the general machinist and toolmaker. A cherry is a milling cutter, usually made integral with an arbor whose length varies with the requirements of the job to be done. The cherry is held in the spindle of the milling machine. The die to be cherried is roughed out on the die-sinking machine as nearly to size as possible and the sprue and gate cut. On dies that are to be cherried the sprue is made semi-circular in shape so as to accommodate the shank of the cherry; that is, the impression in each of the two halves is semi-circular. Next, the die is mounted on the milling machine and the table raised to bring the cherry into

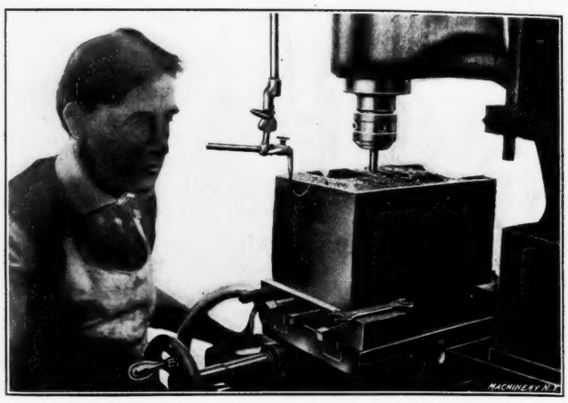


Fig. 34. Milling out a Deep Impression with the Aid of an Indicator

the impression that has been previously roughed out. After the cherry has been carefully centered, the table is raised to bring the cherry to the proper depth into the die, cutting very slowly on account of the large amount of cutting surface involved when the cherry is well into the die. When the impression is deep and is located at quite a distance from the front of the die block, the shank of the cherry must be long, and if the front end of the impression is shallow, the shank of the cherry will necessarily be small in diameter. In such cases, and in fact in all cases where possible, the cutting end of

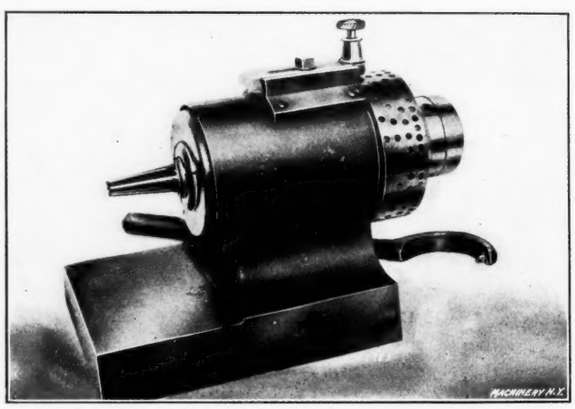


Fig. 35. Fixture for Fluting Cutters, used on the Die-sinking Machine

the cherry should be supported. This support consists of an arm, swung from the supporting arm of the milling machine. The cutting end of the cherry is deeply centered and the support consists of a very short center that is cut away to clear the rest of the die, substantially as shown in Fig. 32.

Fig. 33 shows a group of cherries used in different dies, as accumulated in doing general drop-forge die-sinking, these being of the average type. The operation of cherrying has been described in preference to some of the special milling fixtures because it is the most common method used in this connection. The special fixtures are not found in the majority of die-sinking departments, although the best-equipped shops employ them for special jobs that would be difficult to cherry.

Indicator Used in Making Deep Impressions

Fig. 34 shows a most interesting operation and the indicator used in connection therewith. This die is for making the sister hook illustrated in Fig. 40 and as may be seen, there is a very deep part of the impression used for forming the eye, that would be very difficult to mill out without the fixture shown in this illustration. The main rod of the fixture is screwed or clamped to the body of the die-sinking machine.

* Address: 4 Bailey Ave., East Saugus, Mass.
† Address: 19 Harrington St., Revere, Mass.

This rod terminates in a ball and socket joint from which is supported a cross bar that holds the pointer of the indicator. The die in which the impression is to be milled is laid out as usual, and in addition, a line is scribed on the side of the die that indicates the shape of the bottom of the impression, as projected from the impression that is to be cut. This line may be seen on the side of the die block that is shown on the machine in the illustration, Fig. 34. After the die has been set up on the die-sinking machine, a roughing cutter is held in the chuck and the table of the machine raised until the cutter just touches the top surface of the die. Next, the indicator is adjusted so that the needle is on a line with the surface of the die and at the same part of the scribed outline on that side of the die that agrees with the position of the cutter within the outline of the die impression. With the cutter and indicator thus located, the impression may be roughed out, the die-sinker always keeping the needle of the indicator within the lines on the side of the die. After the die impression has been roughed out, a finishing cutter may be adjusted in the same manner as was the roughing cutter, and by carefully watching the indicator to see that the cutting is always within the scribed lines, the die may be finished much quicker than would be possible without an attachment of this kind.

Cutter Milling Fixture

The die-sinker uses so many special cutters in addition to the regular cutters, that it is essential that he be equipped

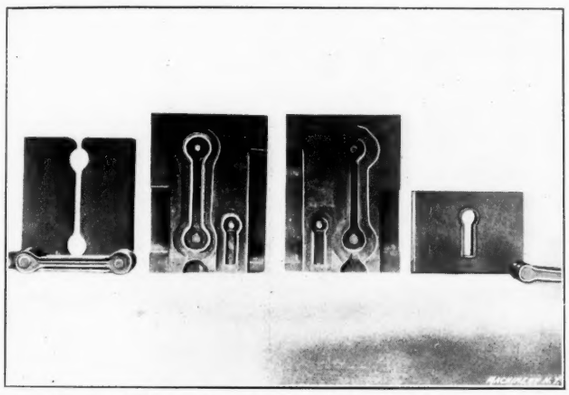


Fig. 36. Set of Dies for Drop-forging and Trimming Shackles and Pins

to make cutters as expeditiously as possible, especially as it often happens that he must stop in the midst of the work of cutting the impression to replace a broken cutter or to make a new shaped cutter. The cutter milling fixture shown in Fig. 35 is a great help in fluting all kinds of die-sinking cutters. As the illustration shows, it is merely a special form of index head, fitted with spring chucks to take the standard sizes of cutter shanks. The fixture is used on the die-sinking machine, using an end mill for cutting the flutes. Both the fixture and its operation are so simple that a description is hardly necessary. The cutter blanks are turned up to the proper clearance angle and fluted while being held in the spring chuck of the fixture. The fixture is held in the vise of the die-sinking machine and the vise swung around enough to give the proper degree to the fluting cut, which on a seven degree cutter would be about five degrees. By means of the indexing arrangement at the back end of the fixture, the cutters may be given any number of flutes desired. It is only necessary to compare the time of setting up this fixture with the time of rigging up a horizontal miller for the job, to see where the advantage of this fluting method lies, especially when it is considered that this operation does not bring another machine into use.

Making Dies for Bronze and Copper Forgings

In making the dies for the production of drop forgings from bronze and copper, there are several points of the work that differ from the making of dies for steel or iron forgings. Foremost among these differences is the finish that must be given the dies. Copper, and bronze as well, are much softer metals than iron or steel, consequently the metal is driven into every detail of the dies during the forging operation. On account of this fact, the dies must be perfectly free from scratches of any kind in order to obtain a copper or bronze forging with a smooth finish. This only means that extra care must be used in polishing out the dies both before and after hardening.

Forgings of copper and bronze are used for machine parts that would be liable to rust from the action of water and also in places that require a non-magnetic metal part. On account of their density they are tougher and harder than a casting of similar metal could possibly be. However, the hammering that is necessary to form such forgings is very hard on the dies, even though the metal being worked is soft. To prevent the dies from dishing or spreading, tool steel is nearly always used for the dies, unless the forgings to be produced are extra large and heavy. The shrink, draft and finish allowances on this class of drop-forge dies are practically the same as on dies for steel and iron. Bronze and copper forgings are trimmed the same as are forgings of iron and steel, but the dies must be kept sharp, in order to do good work; if allowed to become dull, the trimming will be ragged, leaving the forging with a rough surface on the edge.

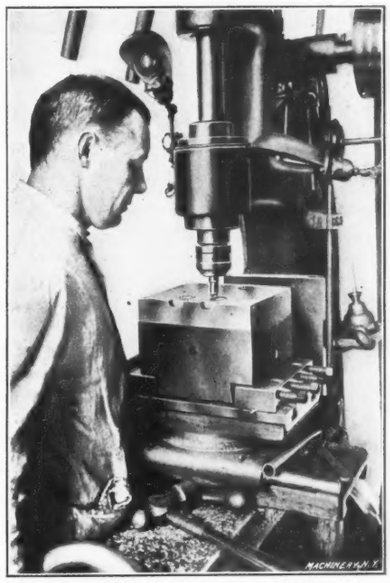


Fig. 37. Starting to Mill out a Drop-forge Die

Dies for Chain Shackles

In making the dies for drop-forging and trimming shackles for chains, we have a representative job of die-sinking, and in addition, there are several special points that are worth noting. Fig. 36 shows a set of dies for drop-forging and trimming a shackle and the pin used in connection therewith. The dies for the drop-forging are the pair in the center and the different parts of the die are well shown, the anvil, breakdown and the central impression. In addition, the impressions for the pin that is put through the shackle after it has been bent to shape, are included at the side of the central impression. The reason for this is that the shackle pin impressions are so small

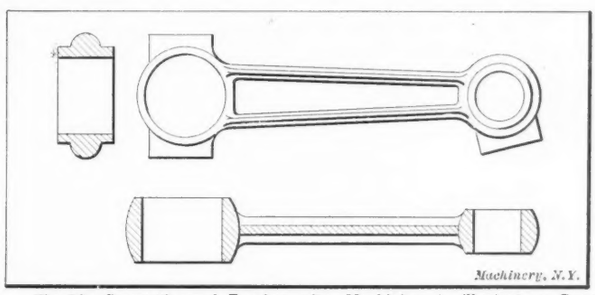


Fig. 38. Connecting-rod Forging, after Machining, to illustrate a Case where Parts of the Die Impression should be milled and typed before the Hub Impressions are milled

that there is plenty of room for them without crowding the main impressions. Another reason, fully as important, is the fact that with every lot of shackles, the same number of pins must be made, and by placing the pin impressions by the side of the shackle impressions the job is set up and ready for use whenever the shackle dies are set up.

Fig. 37 shows the die sinker starting to mill out the impressions in one of a pair of shackle dies. The system of lighting the work, when artificial light is required, is indicated in the illustration where two adjustable incandescent lights are attached to the frame of the die-sinking machine. When these

lights are swung down close to the cutter, every detail of the cutting may be seen, for by the use of two lights, on opposite sides of the work, there is no shadow thrown on the die by the cutter.

The trimming dies for this job are interesting in that they illustrate both styles of dies, hot trimmers and cold trimmers. The die for trimming the shackles shown at the left of Fig. 36 is a hot trimmer, made in one piece. At the front is the punch for this die, recessed out to fit the forging. The trimming die on the right is a cold trimmer for the pin that goes through the shackle.

Connecting-rod Forging

In Fig. 38 is illustrated a forging for a connecting-rod that is shown as a further example of forgings for which the die

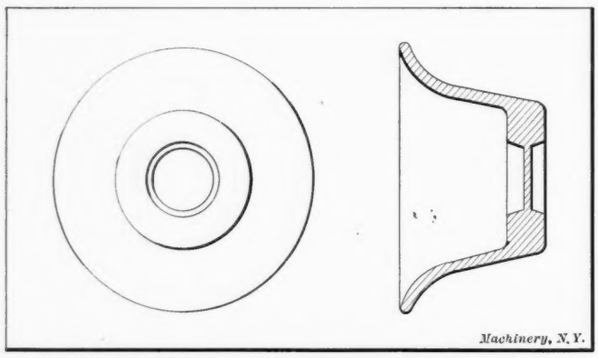


Fig. 39. Thrust Collar, made in a Pair of Dies with but One Set of Impressions; no Breakdown or Anvil required

impressions are best milled and typed for the irregular spots before the central hubs are cut. This illustration shows the finished connecting-rod. The parts that would require typing, are, of course, the projecting lugs through which the bolts pass. The forging for this connecting-rod would be solid at the two ends and into these open places in the impression, the types would naturally slip, should the central opening of the impression be cut out before the projecting lugs were typed.

A Simple Set of Dies for Drop-forging a Thrust Collar

The thrust collar shown in Fig. 39 can be drop-forged in a pair of dies with but one impression. From the illustration, it

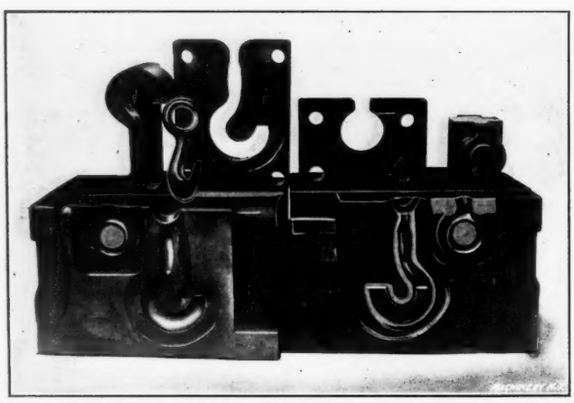


Fig. 40. Set of Dies for Drop-forging and Trimming Sister Hooks

would not seem possible to do this at first thought, but as a matter of fact, it is a practical piece of drop-forging. The secret of the success of this forging operation lies in the preparation of the stock from which the forging is to be made. The stock should be cut into blanks somewhat smaller in diameter than the greatest diameter of the forging, and of such a thickness as will just give stock enough to fill the die, after allowing for a sprue for handling the forging while being worked. The size of this blank can best be obtained by weight, the blank being two-thirds of the weight of the lead proof, after adding enough for the weight of the sprue and an allowance for the shrinkage of the steel in the fire from scaling, etc. The corners of this blank are first hammered in and a short sprue drawn out under the hammer, after which the stock may be placed in the impression of the forging die and struck until full.

No breakdown or anvil are required with this set of dies and the central impression is designed so that the lower die will contain the cavity while the upper half will have the projecting plug. This arrangement is for the purpose of taking advantage of the "shooting up" tendencies of the hot steel. For trimming the central web from the forging, a loose punch is used; that is, a punch that is not fastened in any way to the ram of the trimming press. The cutting end of this punch is made to the size that is wanted for the opening in the forging; back of the cutting edge, the stock is relieved to clear the forging when going through. When used, the punch is pushed through the forging, the punch dropping through the forging to the bolster, from whence it is taken and used again on the next forging. The trimming of this piece should be done hot, although if the central hole is small, that part of the trimming may be done cold. If the hole is trimmed hot, however, the dies will meet much quicker, saving quite a little time in the forging operation.

Dies for Drop-forging Sister Hooks

Another interesting set of dies, shown in Fig. 40, is for drop-forging sister hooks used in the United States Navy. The set consists of the two forging dies and the two pairs of trimming dies, one of which trims the hook end and the other takes care of the ring end of the sister hook. The center of the ring is trimmed by another die not shown. It is obvious that the entire forging could not be trimmed in one operation on account of the two different parting lines on the forging. It is

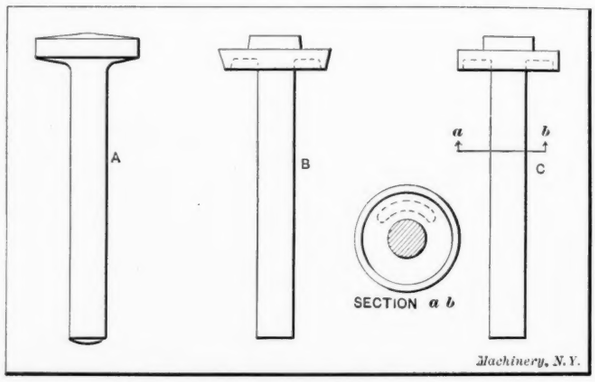


Fig. 41. The Operations of Making a Cam-shaft

also obvious that the shape of the forging makes it necessary to forge each end of the hook separately. To take care of this requirement, an additional set of impressions is cut in the dies to shape the ring at the end of the sister hook. This ring impression is gated the same as the main impression, but it is not used until after the front end of the hook has been completed and the forging with its unfinished ring end has been cut off from the bar. The forgings are made just as though the hook end were solid, being trimmed and cut from the bar leaving the hook end in the shape of a flat disk. Then the ring ends of these semi-completed forgings are reheated and struck in the second set of impressions at the front of the die. It will be noticed that these impressions are gated in such a manner that the hooks will not be crushed while being struck. The stock that is within the center of the ring is more than enough to form the outside in good shape, so no extra allowance need be made.

In the illustration, Fig. 40, the two trimming dies are shown placed on the top of the forging dies. These trimming dies are each made in two halves, being dowelled and screwed to bolsters while in use, a matter that will be more fully treated under the head of trimming dies. In this illustration will also be noticed the way in which trimming punches are cut away to properly support the forging during the trimming operation.

Dies for Upsetting Cam-shaft Forgings

The forging shown at *B*, Fig. 41, is for a cam shaft that is shown, after machining, at *C* in the same illustration. To produce this piece, a forging is made as shown at *A*, in the same

illustration. This is done in a simple pair of dies, having half of the impression in each die. The forging is finished in the pair of dies shown in Fig. 42. A pair of dies of this design are known as "upsetting dies" and consist essentially of a recess to take care of the shank of the forging, confining it

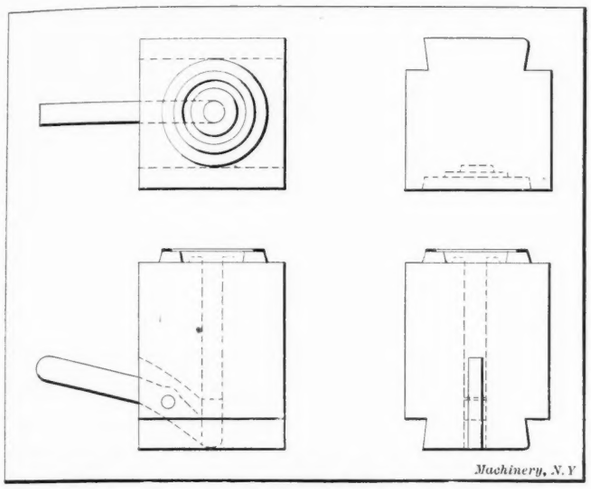


Fig. 42. Upsetting Die for the Second Operation of Forging the Cam-shaft

while a blow is struck to shape the head of the cam shaft in the impressions of the dies. Dies of this kind work after the manner of heading dies used in making rivets and screw blanks, except that they are not split for ejecting. The forging is forced from the die by means of a knock-out, as shown in the illustration. When the blow is struck, the knock-out pin is

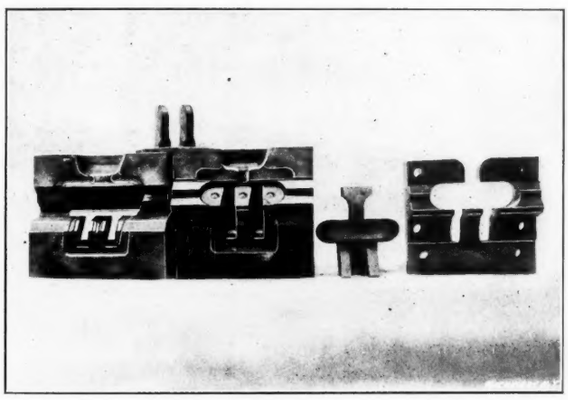


Fig. 43. Lock Dies for Forging and Trimming a Special Hinge

down, resting on the bottom of the die-shoe; after the striking is completed, the forger strikes the knock-out handle with a hand hammer, and the forging is ejected from the die. Ejection is made easier by the fact that the forging is losing heat all the time after the blows have been struck, consequently it is shrinking in diameter. Another precaution, taken to prevent the forging from sticking in the die, is the practice of giving the recess a draft of one-half degree.

The impressions in the faces of the dies, in which the top of the forging is shaped, involve one feature that has not been touched upon before. Around the part of the lower die that contains the impression, the stock is turned down for about one-half inch, leaving the shoulder on a 15-degree bevel. To match this part, the upper die is recessed for the same distance and on the same bevel, thus forming a "lock" that insures the dies properly meeting within close limits of alignment. This particular lock, owing to its form, is called a circular lock. Circular locks are formed on such dies that must produce forgings that are close in dimension or of such a shape that there would be difficulty in setting the dies and holding them in proper alignment without such a help as the lock.

As to the impressions for shaping the top of this cam shaft forging, there is nothing out of the ordinary about them. All parts are sunk with a seven-degree draft, including the sunken section that is the shape of the cam. While being machined, these beveled sides are cut straight. The best method of cutting the arc impression for the cam is by the use of the circular attachment on the die-sinking machine.

A Lock Die for a Hinge

A difficult job of die-sinking is illustrated in the set of dies shown in Fig. 43. This set of dies is for drop-forging the heavy hinge shown on the top of the dies. At the right is the trimming die and punch. In these dies we have a good example of lock dies of another variety, and a more complicated one as well. The forming impression and breakdown for this piece were cut in another set of die blocks as the forging was too large to admit of the various impressions being placed on

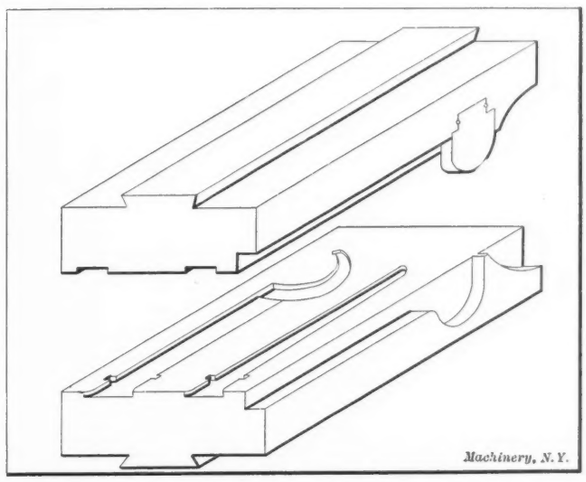


Fig. 44. Drop-forge Dies for Making a Long Forging by Halves, to Obviate the Necessity for Large Dies

the same block. The finishing die shown is the most important and it will be noticed that the draft, flash, gate and sprue are just as much in evidence as they were in the straight type of die. In one of the dies may be noticed the cone-like projections for spotting the centers of holes that are afterwards to be drilled in the forging. The leaves of this hinge are inclined from the base at an angle of 70 degrees. If they were at right angles with the base, the forging of the piece would be simplified a great deal. The hot trimming die shown has its face cut to agree with the parting line of the forging dies, so that the fin will lie against the cutting edge of the die at all points. In cutting the deep parts of the impressions

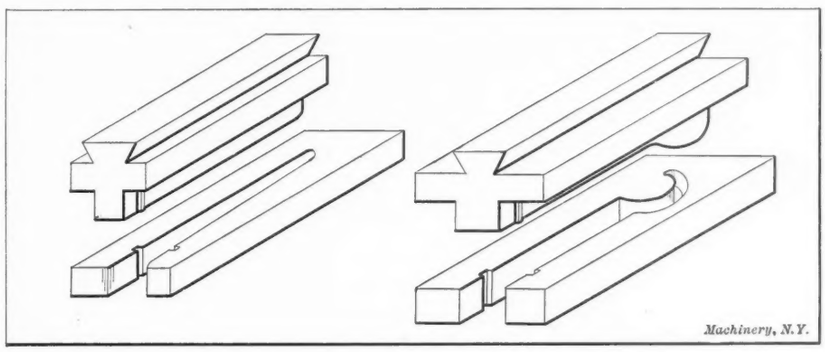


Fig. 45. Trimming Dies for Long Forgings made in Halves

for the leaves of the hinge, the indicator previously described is a great help.

Dies for Making Extra Long Drop Forgings

An extra long forging cannot well be made in a die with one full length impression for several good reasons. First,

the dies would be so large and heavy that the item of stock alone would be almost prohibitive, and second, such dies could only be used in an extra large hammer. The drawing in Fig. 44 shows the method of forging such awkward shaped pieces, taking for example, a long heavy spanner wrench, three feet six inches in length. The impressions of each half of the wrench are cut side by side in the die blocks, keeping in from the edge of the die about one inch. At the halfway point where the two impressions leave off, square notches are cut nearly to the depth of the impressions; these notches are the key-note of the whole method of producing such forgings. They serve as locating points to start the forgings from and they will in this particular die, prevent the metal from sliding forward when struck in the tapering impression for the handle. As the steel fills these notches, it forms lugs on the

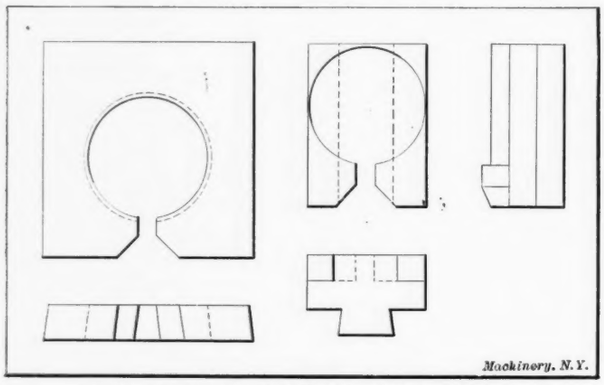


Fig. 46. Illustrating a Plain Hot-trimming Die and Punch

forgings; these lugs fit into the notches in the second impression, thus locating the blank in the proper position. Some forgings would require breakdowns for each end of the piece when made in this manner, but this spanner wrench only requires a breakdown for the hook end. The horn, or bender, is dovetailed into the upper breakdown after the manner previously described.

The method of forging the spanner wrench is as follows. Steel is used that is large enough to make the heavy end of the wrench. One forging is made complete, care being taken to note the length of the bar required to make the forging. After the proper length of the blank has been ascertained, the stock is cut to this size and the entire lot of forgings are made and trimmed on one end. The trimming dies for both ends are shown in Fig. 45. The stock for the handle end of the wrench is then drawn down and forged in the second set of impressions in the dies, using the lugs formed in the first operation as a guide to the proper location for the second operation. In turn, this small end is trimmed as was the forward end, and at last, when the forging is completed, it is moved backward in the trimming die just enough to clip off the lugs on the sides and then struck once more in the dies to round the edges where the lugs were clipped off.

It often happens that the forging is of such a shape that no lugs are required to locate the forging in the second impression. A boss, hub or other projection, either vertical or lateral, does just as well as the lugs just described. With care in the forging, it is possible to make drop forgings of this character within 1/32-inch limits of variation in length.

Trimming Dies

All drop forgings require trimming after the forging proper is done. The ideal forging comes from the dies with a small amount of fin evenly distributed all around the forging, at the parting line. In many ways the fin is to be desired, provided it is uniform. Its presence denotes that the dies are "full" in every respect and after being trimmed, the forging is sure to present a clean edge with all traces of the parting line removed. At the time of the trimming operation, a good part of the draft that has been given the forging may be trimmed off, in case it is detrimental to the finished product.

Trimming dies are of two general classes, called hot-trimming dies and cold-trimming dies, according to the condition the forgings are in when trimmed. These two classes differ materially in their design and in the steel from which they are made, although the die-making operations are similar.

Hot trimmers, as they are called in the shop, trim the fin from the forging while the forging is being made. Fig. 46 illustrates a plain hot-trimming die and punch. Generally, the forging is practically completed, then trimmed and struck again to correct any twists or distortions due to the trimming as well as to bring the edges up sharp and size the forging. In the case of a piece having a large displacement of stock, there is apt to be more fin than in a uniform piece; consequently if this fin is trimmed out of the way just before the forging is finished, it is obvious that the dies will have a better effect upon the forging while striking the finishing blows. Most forgings of the medium and larger classes are hot trimmed.

Cold trimmers must do a great deal harder work than the hot trimmers, and for this reason they are made from high carbon steel and hardened the same as any blanking die. Forgings that are to be cold trimmed are severed from the bar when finished, with the fin untrimmed, and run through the trimming die when cold. Thus it will be seen that to trim other than small forgings in this manner, would be too great a strain upon both punch and die.

Hot-trimming Dies

There is a special grade of steel that is used exclusively for making hot-trimming dies, commonly known as hot-trimming die-stock. The objection to using ordinary tool steel for hot-trimming dies is that the edges of the hardened die check very badly after the die has been in use for a short time. Checking is followed by breaking away of the steel around the edges, rendering the die unfit for use. This special grade of steel, used for hot trimmers, requires no hardening and after the die has been put into use, the edges toughen up and give better service than the best hardened tool steel could possibly do.

Hot-trimming dies, as well as cold-trimming dies, are made either solid or in sections, of which there may be two, three

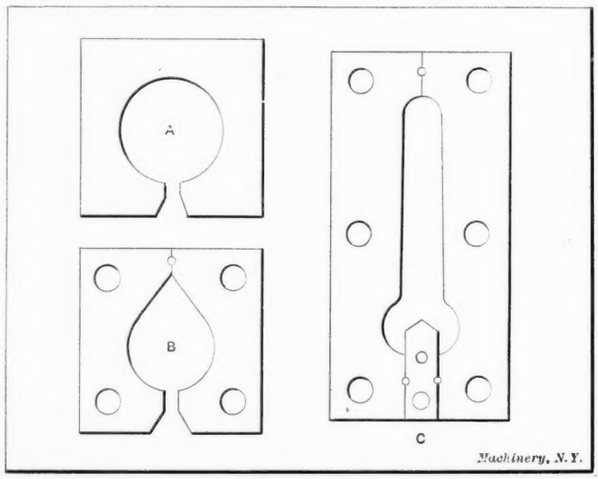


Fig. 47. Trimming Dies: A, One-piece Hot Trimmer; B, Two-piece Hot Trimmer; and C, Three-piece Cold Trimmer

or even more. If the piece to be trimmed is a plain, regular shape, the die is best made in one piece, and at the other extreme, if the forging is a difficult one to trim, the die is built up of two or more pieces; this die construction is a matter to be decided by the die maker. Naturally a one-piece die is much easier to handle in setting up, etc., but a die of two or three sections has the advantage of being more easily sharpened and closed in whenever necessary. Fig. 47 shows the general idea of hot-trimming dies of one and two sections, and a cold trimmer in three sections. As shown, the different sections are properly located by means of dowels set between the sections. A die made in sections must have a special bolster on which the parts are mounted, while a one-

piece trimmer can be mounted on a bolster that is used for other trimming dies.

The main difference in the appearance of hot and cold trimmers lies in the fact that the hot trimmers are left open in the front, while cold trimmers have no openings of this kind. The opening in a hot-trimming die is for the purpose of clearing the sprue that connects the forging to the bar, otherwise the forging would be severed from the bar at the first trimming operation. As hot-trimmed forgings are trimmed two or three times in the forging operation, it is of course, necessary that the forging should remain intact with the bar until it is finished. The trimming die is made to trim the sprue section as well as the forging itself. After the forging is completed, it is cut off at the sprue by means of the special cut-off on the side of the trimming press. The opening at the front is cut clear through the thickness of the die stock, and there must be a corresponding opening through the bolster, so that the forgings may be carried through the die and bolster after trimming and taken out from beneath. The die shoe is made with an open space in the center beneath the die and bolster, therefore when the forging is trimmed, it drops through the die and bolster into this open space and is drawn out through the front of the shoe, still intact with the rest of the bar of steel. The positions of the die, bolster and shoe are graphically shown in Fig. 48.

Making a Hot-trimming Die

In making a hot-trimming die, the templet used in laying out the outline for the impression in the drop-forging dies

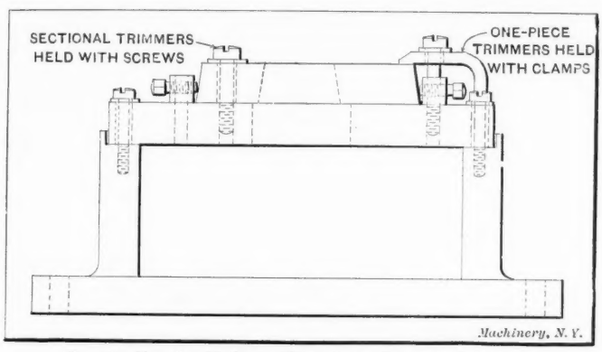


Fig. 48. Showing Method of Mounting a Trimming Die on the Bolster and Shoe

comes into use again, for with it the trimming die may be laid out. The shrinkage allowances in this case are correct, being the same in the trimming dies as they were in the forging die. In connection with the templet, a half-lead should be taken from the forging dies, using the top die for the purpose. A half-lead is easily taken by standing the die on end and clamping a piece of steel or iron over its face, and pouring the molten lead in the ordinary manner. This half-lead must be replaced in the impression after pouring, and the edges peened out to fill the impression when it is cold, for the shrinkage spoils it for use as a templet without this peening. The reason for taking this lead from the top die is that the forging is usually laid in the trimming die with the same side up as it is in the forging die, so as to be convenient for the forger. Using the lead from the top die as a templet will give the trimming die the proper outline to agree with the forging die without reversing. Another reason for using the top half of the lead, is due to the fact that it is easier to fit the die to the top half-lead than the bottom half-lead. The die is tried by pushing the lead up through the back side of the die at intervals during the filing. It is obvious, therefore, that the impression side of the top lead will show up the places in the die that must be filed out, far more clearly than would the flat side of the bottom half-lead, in case it were used.

After the die has been laid out and the outline lightly prick-punched, then a row of holes is laid out the edges of which just clear each other and the outline of the die opening. The size of these holes is dependent upon the size of the die to be made; but for other than small dies, one-half inch is a good size for the holes. After these holes are drilled, the central core may be knocked out and the die is ready for milling.

Fig. 49 illustrates the operation of milling out a trimming die. The die is set up in the vise of the die-sinking machine and a stiff, straight cutter is held in the chuck. With this cutter the die is milled up to the scribed outline, cutting away the rough stock left by the drilling operation. The cutting section of this cutter should be long enough to extend through the entire thickness of the die. After the opening is roughed out, the straight cutter should be replaced by a three-degree cutter that is made with the larger diameter at the bottom. With this cutter the stock may be taken out just to the line. Next, the die should be turned bottom side up in the vise, and a four-degree cutter of the regular die-sinking type placed in the cutter chuck. This cutter should be entered into the opening in the die to within 7/16-inch of the face of the die (which is now at the bottom), and a clearance milled all around the opening, about as shown at Fig. 50. As this illustration shows, this method of putting in the clearance leaves a sort of shelf about one-third the distance from the face of the die to the bottom. Trimming dies are, on an average, 1½-inch thick; therefore, with the above clearance, there will be less than ½ inch to file at those points and corners that require filing.

Fig. 49. Milling out a Trimming Die

Should the die be composed of more than one piece, the sections must be fitted and dowelled for alignment before drilling or milling, after which they may be clamped together in the vise of the die-sinking machine just as though they were one piece and treated that way during the milling operations. After the milling has been completed, some filing will be necessary to smooth up the cutting edge and to clean out any corners or angles that could not be milled. For a one-piece die, no holes are required to hold the die to the bolster, as that feature is taken care of by the clamps and side screws with which the bolster is supplied; this feature is illustrated in Fig. 48. This style of a bolster is used only with one-piece trimmers. If the trimmer is made up of more than one piece, the parts must be screwed and dowelled to the bolster.

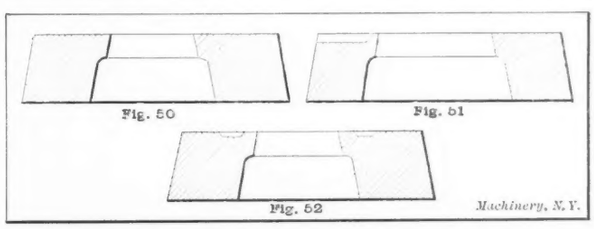


Fig. 50. Section of Trimming Die to show the Clearance given to the Cutting Edge. Fig. 51. Section of Cold Trimmer to show Method of Cutting away a Space at the Front to clear Rough Sprues. Fig. 52. Section of Trimming Die to show Channel Cut around the Die-opening to accommodate Forgings that must be trimmed Wrong-side up

Punches for Hot-trimming Dies

The general idea of a punch for a hot-trimming die is not to cut, but to support the forging while it is being pushed through the die. If the forging has a broad flat top face, the trimming punch need be little more than a flat punch that covers the top of the forging and acts as a "pusher" without regard to

the size of the die itself. Such punches are commonly made of cast iron, and for wrench forgings and other flat work, especially of the larger class, they answer the purpose as well as a steel punch. A wood pattern is usually made, and the casting from it will require little machining before it is ready for use. If the forging is of a round section, the punch must be hollowed out to fit the top face of the piece. There is but one part of the forging where the punch should fit fairly well and that is the sprue section, for unless this part is fitted close, it will bend up and make extra work for the forger. On the other parts of the die it is an advantage to have the punch fit the die very loosely, so that the fin will not stick

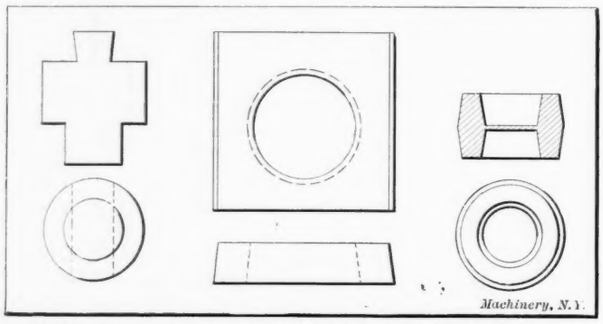


Fig. 53. Trimming Inside and Outside of a Ring Forging at the Same Time

to the punch during the trimming. Punches for hot trimming are not usually hardened and they are held in the ram of the trimming press by means of a taper shank and key.

Cold-trimming Dies

Cold-trimming dies are made from good tool steel, 100 to 125 point carbon, and after making are hardened and drawn to a dark straw color. The machine operations in the making are the same as with the hot trimmers except that the opening at the front is omitted because the forgings are not trimmed until they have left the forging press, cut from the

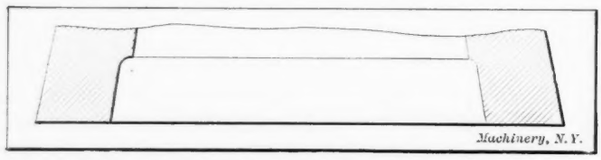


Fig. 54. The Way in which Long Trimming Dies are Sheared

bar at the sprue. Although trimming dies for cold work are not made with an opening in the front, there is usually a shallow space cut away just outside of the cutting edge at the front of the die to clear the ragged end of the sprue that is necessarily left after being severed in the cut-off of a pair of drop-forging dies. This clearance appears about as shown in the illustration, Fig. 51.

In laying out the cold trimmer for a drop forging, the shrinkage problem comes up again. One of the best methods of obtaining the outline, is to measure with a shrink rule the templet that was used in laying out the drop-forging dies,

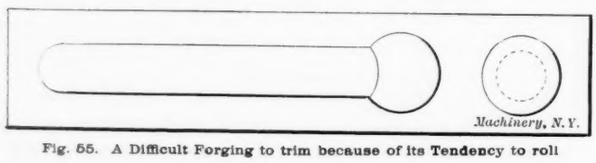


Fig. 55. A Difficult Forging to trim because of its Tendency to roll

and to make the outline of the trimming die to these dimensions as read from a standard rule. In making a cold-trimming die, it is a wise plan to first trim up one of the forgings by hand and then to keep away from the lines of the trimming die until it is sure that they are going to be correct for the actual forging. With this precaution it will be easier to fit the forging closer, for there is always a little uncertainty due to the difference in shrinkage arising from the use of the different steels from which the forgings are made.

The average thickness of trimming dies lies between one and two inches, probably being nearer the one-inch limit on small and medium work. In the case of lock dies, the thickness will depend upon the amount of irregularity caused by the parting line of the forging dies. The surfaces of some cold-trimming dies are cut away to within ¼-inch of the cutting edges of the dies. The reason for this is that on account of their shape, it is often advisable to trim some forgings in the opposite direction to that in which they were forged. This is not often necessary, but when it is, the trimmer must be cut away to clear the back flash that is left on the upper side of most fins. Such a trimming die is shown in Fig. 52. On account of the fact that in drop forging, the steel is more easily forced up than down, into the dies, high projections would be in the upper dies, but it would be rather awkward to trim such forgings, from this direction. For this reason the die is cut away as shown and the forging trimmed in the opposite way.

Punches for Cold-trimming Dies

The punches for cold trimmers are made from tool steel, and are hardened and drawn to a very dark straw color. These punches are not hardened to make them cut better, but to prevent them from upsetting at the edges. As with hot-trimming punches, the punch should fit the die loosely, but it should support the forging at every point while it is being pushed through the die.

There are two cases in which trimming punches must fit the dies as closely as the average blanking die for sheet metal work. One case is in trimming forgings on which the fin comes at the corner of the forging and the other case is similar, being on forgings that are formed all in one die, having the other die flat. Unless the dies fit fairly well, burrs will result at the trimmed edges of such forgings.

Trimming a Ring Forging

Fig. 53 shows a trimming die that trims the inside and outside of a ring forging at one operation. The die is a hot trimmer and made to fit the outside edge of the ring at the parting line. The punch is made with a projecting pilot punch that just fits the inside of the ring at the parting line, while the shoulder that pushes the fin off from the outside edge of the forging, is left far enough from the face of the pilot punch to allow the center web to be cut out before the shoulder strikes the top face of the ring. The forging is laid in the trimming die, the punch comes down and cuts out the central web before the shoulder of the punch reaches the top face of the ring. As soon as enough pressure is brought upon the top of the ring, the outside fin and the sprue are trimmed off. With this style of a punch and die, it is best to trim the outside very close, cutting off some of the draft so as to give more support to the punch while trimming the inside fin. The die will not require a stripper as might be supposed, for the inside punch will strip itself owing to the fact that it cannot draw the forging back through the trimming die. The inside punch should be no longer than necessary and should have a very slight taper toward the cutting edge.

General Notes on Trimming Dies

Trimming dies for forgings that are very irregular in shape, having been forged in lock dies, must have the surface of the trimming die, whether a hot or cold trimmer, shaped to agree with the face of the drop-forging die. The reason for this is very apparent, the object being to prevent the bending of the forging while being trimmed. A good example of this point is shown in the trimming and forging dies illustrated in Fig. 43.

Forgings that are to be cold trimmed should be pickled in a weak solution of sulphuric acid to remove the scale formed in the forging operation; by so doing, the dies will last much longer, saving the cutting edge from the hard scale that otherwise would have to be cut in trimming the forging.

A particularly difficult piece to trim is shown in the illustration, Fig. 55. The difficulty lies in the tendency of the forging to roll in the dies while being trimmed. If the forging is matched this tendency will be reduced, but even then if conditions are not of the best, the forging will not trim well. One way of helping to overcome this rolling tendency, is to roughen the surface of the punch where it comes in contact with the forging. This causes the punch to grip the surface of the forging, but it also tends to mar the forging.

If the outline of the forging to be trimmed is long, or of a large perimeter, it will be a good plan to shear the die. Fig. 54 shows the method of shearing a trimming die by grinding hollows in its surface at intervals. This, of course, lessens the force required for the trimming, or rather it divides the work of trimming, whereas in the case of a straight die, the trimming must be all concentrated into one stage of the blow.

By making the trimming die slightly smaller than the outline of the die impression, it is possible to trim off some of the draft that was given the forging in the dies. The appearance of this bevelled edge of the forging is often considered objectionable and by making the trimming die small, most of the draft may be shaved off.

Credit is due Naval Constructor Geo. H. Rock of the Boston Navy Yard, and Asst. Naval Constructor J. E. Otterson in charge of the drop-forge die-sinking department for the assistance given and the courtesy shown the authors while securing photographs of the die-sinking operations illustrated in these articles.

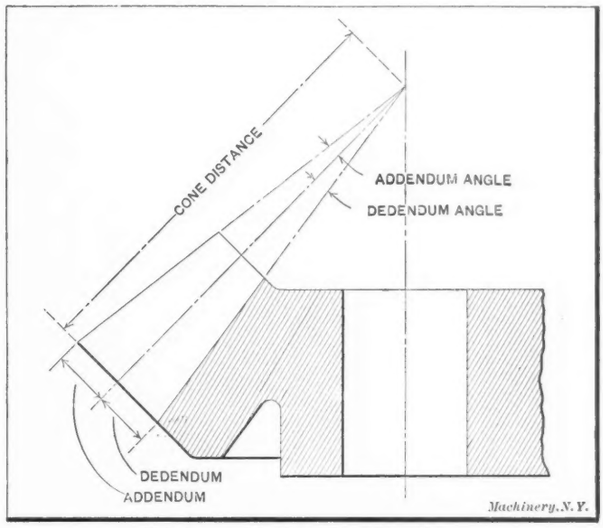
TABLE OF DEDENDUM ANGLES FOR DIFFERENT ADDENDUM ANGLES

Minutes	Degrees 0		1		2		3		4		5	
	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.
0	0	0	1	9	2	19	3	28	4	38	5	47
1	0	1	1	11	2	20	3	29	4	39	5	48
2	0	2	1	12	2	21	3	31	4	40	5	49
3	0	3	1	13	2	22	3	32	4	41	5	51
4	0	5	1	14	2	23	3	33	4	42	5	52
5	0	6	1	15	2	25	3	34	4	44	5	53
6	0	7	1	16	2	26	3	35	4	45	5	54
7	0	8	1	18	2	27	3	36	4	46	5	55
8	0	9	1	19	2	28	3	38	4	47	5	56
9	0	10	1	20	2	29	3	39	4	48	5	58
10	0	12	1	21	2	30	3	40	4	49	5	59
11	0	13	1	22	2	32	3	41	4	50	6	0
12	0	14	1	23	2	33	3	42	4	52	6	1
13	0	15	1	24	2	34	3	43	4	53	6	2
14	0	16	1	26	2	35	3	44	4	54	6	3
15	0	17	1	27	2	36	3	46	4	55	6	5
16	0	19	1	28	2	37	3	47	4	56	6	6
17	0	20	1	29	2	39	3	48	4	57	6	7
18	0	21	1	30	2	40	3	49	4	59	6	8
19	0	22	1	31	2	41	3	50	5	0	6	9
20	0	23	1	33	2	42	3	51	5	1	6	10
21	0	24	1	34	2	43	3	53	5	2	6	11
22	0	25	1	35	2	44	3	54	5	3	6	13
23	0	27	1	36	2	45	3	55	5	4	6	14
24	0	28	1	37	2	47	3	56	5	6	6	15
25	0	29	1	38	2	48	3	57	5	7	6	16
26	0	30	1	40	2	49	3	58	5	8	6	17
27	0	31	1	41	2	50	4	0	5	9	6	18
28	0	33	1	42	2	51	4	1	5	10	6	20
29	0	34	1	43	2	52	4	2	5	11	6	21
30	0	35	1	44	2	54	4	3	5	12	6	22
31	0	36	1	45	2	55	4	4	5	14	6	23
32	0	37	1	46	2	56	4	5	5	15	6	24
33	0	38	1	48	2	57	4	6	5	16	6	25
34	0	39	1	49	2	58	4	8	5	17	6	26
35	0	41	1	50	2	59	4	9	5	18	6	28
36	0	42	1	51	3	1	4	10	5	19	6	29
37	0	43	1	52	3	2	4	11	5	21	6	30
38	0	44	1	53	3	3	4	12	5	22	6	31
39	0	45	1	55	3	4	4	13	5	23	6	32
40	0	46	1	56	3	5	4	15	5	24	6	33
41	0	47	1	57	3	6	4	16	5	25	6	35
42	0	49	1	58	3	7	4	17	5	26	6	36
43	0	50	1	59	3	9	4	18	5	27	6	37
44	0	51	2	0	3	10	4	19	5	29	6	38
45	0	52	2	2	3	11	4	20	5	30	6	39
46	0	53	2	3	3	12	4	22	5	31	6	40
47	0	54	2	4	3	13	4	23	5	32	6	42
48	0	56	2	5	3	14	4	24	5	33	6	43
49	0	57	2	6	3	16	4	25	5	34	6	44
50	0	58	2	7	3	17	4	26	5	36	6	45
51	0	59	2	8	3	18	4	27	5	37	6	46
52	1	0	2	10	3	19	4	28	5	38	6	47
53	1	1	2	11	3	20	4	30	5	39	6	48
54	1	2	2	12	3	21	4	31	5	40	6	50
55	1	4	2	13	3	23	4	32	5	41	6	51
56	1	5	2	14	3	24	4	33	5	43	6	52
57	1	6	2	15	3	25	4	34	5	44	6	53
58	1	7	2	17	3	26	4	35	5	45	6	54
59	1	8	2	18	3	27	4	37	5	46	6	55

TABLE OF DEDENDUM ANGLES FOR BEVEL GEARS

By E. WINSLOW BAXTER

When it is necessary to make calculations for bevel gears whose shafts are not at right angles, or where the depth of tooth is greater or smaller than the standard depth for the thickness of tooth used, it is not possible to make use of the tables for finding the addendum and dedendum angles, given in the various hand-books. The accompanying table is designed to save much of the labor of calculation in such cases. After the addendum angle is figured by the formula $\frac{\text{addendum}}{\text{cone distance}} = \text{tangent of addendum angle}$, reference is made to the table



Notation used for Bevel Gear Formulas

to find the dedendum angle which is worked out from the following:

Dedendum angle = 1.157 × addendum angle.

Of course the tab'e cannot be used where the ratio of dedendum to addendum is different from that of the standard Brown & Sharpe tooth parts.

Example: Find the dedendum angle for a given addendum angle of 3 degrees 43 minutes. At the intersection of the vertical column under 3 degrees and the horizontal line opposite 43 minutes, the answer, 4 degrees 18 minutes, is found.

* * *

The report of the Swedish Iron and Steel Institute for 1910 contains some interesting data relating to the results of the experiments undertaken in order to ascertain the practicability of the smelting of iron ore by electricity. The results obtained, says the report, show that the problem of smelting iron ore by electricity is solved even from the economical standpoint, on condition that electricity can be furnished at a cheap rate, the same as is now the case at Trollhättan, where the experimental smelting works are located. The experiments have thus far paid expenses. It has been said, however, by engineers connected with the iron industry that while the experiments have been successful, they have not indicated any advantage over smelting with ordinary coal. Nevertheless, the new process may prove profitable in the North or Sweden, where there is an immense supply of water power and great deposits of high-grade ore, but where there is no supply of coal.

* * *

The German patent law at the present time provides that the authorities may revoke a patent if the inventor neglects to work it adequately in the country within the first three years of the life of the patent. An amendment to the patent law is now proposed according to which the authorities are empowered to compel the licensing of the patent, instead of revoking it.

* Address: 33 Flynt St., Norfolk Downs, Quincy, Mass.

Copyright, 1911, by THE INDUSTRIAL PRESS

Entered at the Post-Office in New York City as Second-Class Mail Matter

MACHINERY

DESIGN—CONSTRUCTION—OPERATION

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS

49-55 LAFAYETTE STREET, CORNER OF LEONARD
NEW YORK CITY

Alexander Luchars, President and Treasurer
Matthew J. O'Neill, Secretary

Fred E. Rogers, Editor.
Erik Oberg, Franklin D. Jones, Douglas T. Hamilton,
Associate Editors

The receipt of a subscription is acknowledged by sending the current number. Checks and money orders should be made to THE INDUSTRIAL PRESS. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Single copies can be obtained through any newsdealer.

We solicit exclusive contributions from practical men on subjects pertaining to machine shop practice and machine design. All accepted matter is paid for at our regular space rates unless other terms are agreed on.

SEPTEMBER, 1911

PAID CIRCULATION FOR AUGUST, 1911, 25,789 COPIES

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition, $1.00 a year, which comprises approximately 700 reading pages. The Engineering Edition—$2.00 a year, coated paper $2.50—contains all the matter in the Shop Edition, about 300 pages a year of additional matter and forty-eight 6 x 9 Data Sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. The Railway Edition, $2.00 a year, is a special edition including a variety of matter for railway shop work—same size as Engineering and same number of Data Sheets.

SEVENTEENTH VOLUME OF MACHINERY

The seventeenth yearly volume of MACHINERY was completed with the August number, and the index of contents will be sent to any reader upon receipt of request. The index for the seventeenth volume is made up in the same form as that employed for the preceding volume, all the articles and page numbers for the engineering, shop and railway editions being comprised in one.

A retrospect of the volume just completed is a matter of satisfaction to those responsible for the contents. It calls attention to so great an array of articles touching on the varied features of machine design and construction that the mere naming of the principal ones would be too long for this page, interesting though it might be to casual readers. But of even greater interest to these and the regular subscribers will be the articles published in the coming year. Processes regarded in some quarters as trade secrets will be described in detail, and many improved methods of doing common work will be shown. The advantage of being a regular subscriber will be even greater than in the past.

* * *

WHY ARE OUR FOUNDRIES NEGLECTED?

We were recently asked by a European engineer of high reputation, who had traveled in the United States and made a careful study of our manufacturing methods, why our foundries are neglected while our machine shops are so efficiently operated. It was a difficult question to answer, particularly as we had not previously realized that our foundries were neglected. But so many instances of inefficiency in our foundry work were pointed out, and so many comparisons made to our disadvantage with foreign results, that we could not deny that the foundries in the United States in general are not worked as efficiently as the machine shops. The engineer mentioned is himself a foundryman and thoroughly conversant with the efficient working of a foundry. He admitted that most of our foundries are well equipped with modern appliances, but his criticism was that they are not managed efficiently.

Our machine shops are generally far more efficiently organized than our foundries; this may be because the management of the latter is often given over to foremen selected from the ranks of the molders on account of their skill as such, but lacking in other knowledge, and especially in the ability to develop new ideas and break away from the old methods in which they have been trained. In our machine shops the management is usually in the hands of men who are not only good mechanics, but full of new ideas and anxious to try them out, because success in that direction means profit and advancement. To raise our foundries to the same level of efficiency as our machine shops, it may be necessary to place them in charge of men having greater mechanical ability and better education, and with a more liberal tendency toward change than has been the case in the past. In Europe many firms employ engineers of high standing in charge of their foundries, and we might perhaps profit by their example.

* * *

SCIENTIFIC MANAGEMENT OF RAILWAY SHOPS

When Louis D. Brandeis made his famous declaration before the Interstate Commerce Commission last winter that the railroads were losing a million dollars a day through inefficient management, the statement was treated with derision by many railway officials, who resented the idea that an outsider was capable of pointing out opportunities for improvements to which they were blind. That there is an opportunity for improvement is now tacitly admitted by the action of several leading roads which have lately instituted searching investigations into the general management of train movements, maintenance-of-way and repairs of locomotives and cars.

Those who have visited railway repair shops and noted the conditions under which work is done in some of them must have been struck with the lack of proper tools and appliances to perform work expeditiously and economically. One such case recently came to our attention in a Southwestern railway repair shop, where a double-end punching and shearing machine with a capacity to punch a 3-inch hole through 2-inch material and to shear 4½-inch round soft steel bars, cold, was employed punching ¾-inch holes through boiler plate about ⅝ inch thick, and shearing 1-inch round bars.

On calling the attention of the mechanic in charge to the heavy over-head expense of operating so large a machine on such light materials, the visitor was informed that the condition was fully realized, but that it had been impossible for him to get through requisitions for lighter machines more suitable for the general run of work.

Between a large costly machine, slow in movement and therefore expensive to operate, and one too small and weak for part of the general run of work, there is little to choose on the score of economy. It is true that the large machine can handle everything that comes to it, but its operation results in waste of time and extra expense because of the overhead burden. The weak machine is more desirable for the work within its capacity, because of its more rapid movement and the smaller investment, but suffers in comparison when employed on materials too heavy for its normal capacity. Between these extremes there is a happy medium which it is the duty of the investigator to determine.

It is a poor policy in general to purchase machine tools or to build manufacturing plants to cope with remote conditions of expansion or development. It is more in keeping with the principles of scientific management to build the plant or purchase the tools for present average conditions of work, and let the future care for itself. In railway repair work certain abnormal conditions exist because of rapid expansion, but though the increase of power and size of locomotives has been rapid for the last ten years, it is safe to assume that the change in the next twenty years cannot be as great. The limitations of track, gage, bridges and tunnels will prevent any great increase in the width and height of locomotives. Therefore it seems that machine tools of all classes suitable for railway work can be designed to meet average conditions likely to continue for a generation to come—a period that measures the efficient life-time of machinery in general.

UNPROFITABLE PATENTS

We described in the July number a tool, lately patented, for extracting tight shaft keys from the hubs of pulleys and gears, which no doubt was useful in the shop where it was designed and made, but which did not warrant the expense necessary to secure a patent, because of its obviously limited use. The probabilities are that the inventor will never receive in royalties a sum sufficient to pay the postage on the correspondence incident to securing the patent.

This case would not merit attention were it not typical. The fact that a device is novel and useful is not a guarantee that it will be profitable. The inventor should consider the probable market, and the cost of selling as well as of manufacturing. The devices that bring the largest returns to the inventors are those that meet a general want. A simple household convenience, or any article of general utility, may become a staple and yield large profits. On the other hand, a very ingenious tool may have so limited a use as to be valueless to the inventor except in his own business. Between the articles having a wide sale and those required in such small quantities as not to warrant manufacturing, there is a broad middle ground, in which many inventions lie, and the relative nearness of the new invention to one limit or the other determines its commercial value.

* * *

SHEET-METAL WORKING ON A SCIENTIFIC BASIS

The engineer who developed the sclerescope, an effective and simple instrument for testing the hardness of metals, has had a peculiar experience in connection with its introduction. This instrument has been sold to many progressive concerns, and is in use for a wide variety of testing purposes, but the originator has been unable to obtain from a large number of users any definite knowledge of the uses to which the instrument is being put, or any data resulting from their experience with it. The condition mentioned has been especially true of the sheet-metal industry.

This selfish policy has materially retarded the development of the sheet-metal industry along scientific lines, and numerous cases have been found where costly die work could have been avoided if the hardness of the material in the first instance had been known. In designing bending punches and dies, experiments are necessary under present conditions each time a different form is to be produced, and also if the same form is required when the part is made from different material. The use of a testing instrument such as we have referred to does away with all but the first experiment, and the work connected with that would be greatly simplified by tabulating the results of experiments. This desirable object can be accomplished by ascertaining the hardness of the metal and obtaining a factor for a certain bend, when produced in a piece of material of a given hardness and thickness. It would be necessary, however, to make a series of tests on the different materials, such as copper, brass and steel, as a comparison of the hardness of these metals cannot be used as a basis.

The following case is a good example of the time and money wasted on experiments as they are now conducted in connection with such work. A certain spring was required for an electric apparatus to be made from German silver, and to an exact shape. The bending dies were designed, and as is the common practice, their shape was determined by trial. These dies were made and after considerable experimenting the supposedly correct shape to give the desired bend was obtained. The dies were then turned over to the press department, when it was found that there was not sufficient German silver in the store-room to complete the order. A new lot was obtained, but when the dies were completed it was found that they did not produce the desired bend. As a large supply of material had been ordered and furnished according to specifications, the only alternative was to anneal the dies and experiment—a second time—with the new material.

Another case in which a hardness testing device would save unnecessary work is in the making of dies for drawing sheet-metal. The mechanic must now depend entirely on the results of his personal experience, memory of which is more or less vague. He cannot tell exactly how much the metal will stretch, nor what hardness it will develop until the dies are completed. All he knows of the hardness of, say, brass, is that there are three grades, *viz.*, soft, half-hard and hard, and between these degrees exist factors unknown to him. This lack of definite knowledge makes experiments necessary with steel—a costly process when anything except ordinary drawing or press working of sheet metal is to be undertaken. Experimenting in the tool-room is often unsatisfactory, usually expensive. If it is impossible to determine the characteristics of the sheet material the work may be of little or no future value, because a slight variation in the hardness of the metal may make the tools unsuitable.

It is quite plain that the sheet-metal working industry as a whole has much to gain from cooperative work, and in order to reap the benefits of cooperation, it will first be necessary to publish the results of tests made in the course of tool-making, or to give the designer of the testing instrument the data resulting from its use.

* * *

SPIRAL GEAR DESIGN—1*†

By JAMES H. CARVER‡

To the average machine designer, a problem in spiral gearing is not an every day occurrence. When such a problem is met with, say once in six months or in a year, he begins to hunt up some of the literature which he thinks may contain the required information, but which is not always available in convenient form. In the following are, therefore, given the data needed and the methods of solving the eight cases mostly used, with the hope that this information will be of use when occasion arises.

The eight cases mentioned are:

1.—Shafts parallel, ratio equal, and center distance approximate.
2.—Shafts parallel, ratio equal, and center distance exact.
3.—Shafts parallel, ratio unequal, and center distance approximate.
4.—Shafts parallel, ratio unequal, and center distance exact.
5.—Shafts at right angles, ratio equal, and center distance approximate.
6.—Shafts at right angles, ratio equal, and center distance exact.
7.—Shafts at right angles, ratio unequal, and center distance approximate.
8.—Shafts at right angles, ratio unequal, and center distance exact.

In the accompanying Data Sheet Supplement, the procedure to follow in calculating the required dimensions for each of the first four cases is outlined. In a following number of MACHINERY, the last four cases will be treated. All the required formulas are given, and also an example, showing the application of the formulas to a practical problem. All the information necessary for the shop operations is given, including the number of teeth marked on the spur gear cutter used, and the lead of the spiral, which data are often omitted on the drawing, but which always ought to be given. If omitted, the operator of the milling machine or gear-cutter must determine these data himself, or hunt up the shop scholar, who does it for him, and this is not a commendable method.

Procedure in Calculating Spiral Gears

One of the first steps necessary in spiral gear design is to determine the direction of the thrust, if the thrust is to be taken in any particular direction. The direction of this thrust being determined and the relative position of the driver and driven gear being known, the direction of spiral (right- or left-hand) may be found. The accompanying thrust diagram for gears having parallel shafts can be used advantageously as an aid in finding the direction of spiral. The direction

* With Data Sheet Supplement.

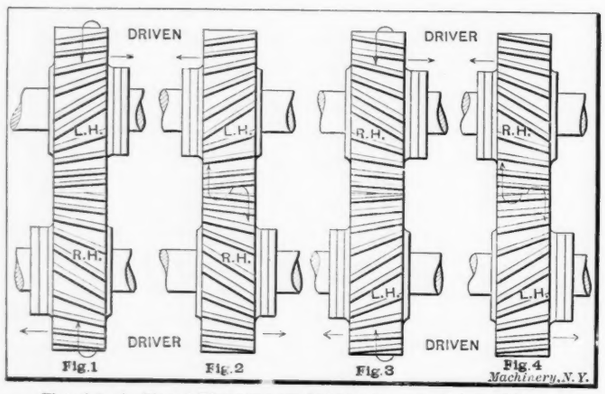
† For articles previously published on this and kindred subjects, see MACHINERY, October, 1908, engineering edition, "Diagrams for Designing Spiral Gears"; April, 1908, "A Study in Spirals"; April, 1908, engineering edition, "Derivation of Formula for Determining Spur Gear Cutter Number for Spiral Gears"; June, 1907, "A Comparison of the Efficiency of Two Trains of Spiral Gears"; May, 1906, "A Method of Procedure in the Design of Helical Gears." See also MACHINERY'S Reference Series book No. 20, "Spiral Gearing," and MACHINERY'S Data Sheet book No. 6, "Bevel, Spiral and Worm Gearing."

‡ Address: 761 Eastern Ave., Schenectady, N. Y.

of the thrust on spiral gears depends on the direction of spiral, the relative positions of driver and driven gear, and the direction of rotation. If the exact condition with regard to thrust is not found in the diagram, it may be obtained by changing any one of the above three conditions; that is, in Fig. 1 the thrust may be changed to the opposite direction, by interchanging driver or driven gear, by reversing the direction of rotation, or by changing the direction of spiral. Any one of these alterations will produce a thrust in the opposite direction. The conditions of design will determine the nature of center distances, whether they must be exact or approximate. The strength of tooth needed, or sometimes the cutters on hand, will determine the normal pitch of the gear. The formulas given for the different conditions of spiral gearing are all based on the normal diametral pitch which is the same as the diametral pitch of the cutter used. The number of teeth in each gear is, of course, determined by the required speed ratio of the shafts. The angle of spiral depends on the conditions of the design, and the relative position of the shafts. If the shafts are parallel, the gears may be of the herring-bone type, when an angle as great as 45 degrees may be used, as there is no end thrust. When used as shown in the thrust diagrams, the spiral angle should not exceed 20 degrees, thus avoiding excessive end thrust. In order to obtain smooth running gears, the spiral angle should also be such that one end of the tooth remains in contact until the opposite end of the following tooth has found a bearing, as indicated at *V* and *W* in Fig. 6.

1. Shafts Parallel, Ratio Equal, and Center Distance Approximate

This case is met with in new designs, where an exact center distance is of no importance. The five factors, direction of spiral, approximate center distance, normal diametral pitch, number of teeth, and angle of spiral are first determined upon. Then, from the formulas given in the Data Sheet Supplement, the required data are found as shown in the example given. The following shows the derivation of the formulas; in Fig. 5, let a be the angle of spiral with the axis of the gear; let H

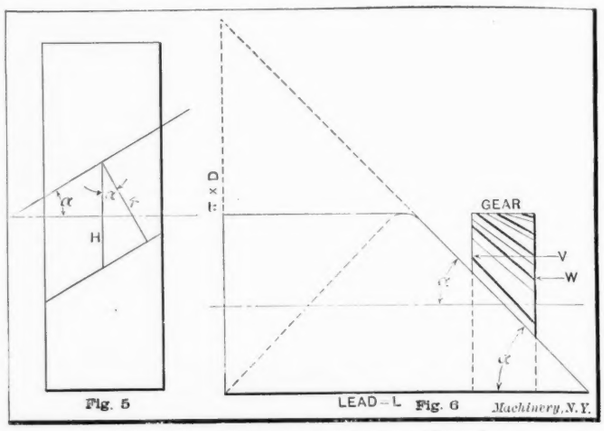


Figs. 1 to 4. Thrust Diagrams for Spiral Gears—Direction of Thrust depends upon Direction of Rotation, Relative Position of Driver and Driven Gear, and Direction of Spiral

be the distance from one tooth to the next, measured on the circumference of the pitch circle, and K the normal circular pitch of the gear. Then $H = \frac{K}{\cos a}$. The diametral pitch $= \frac{\pi}{\text{Circular Pitch}}$. Let P_n = normal diametral pitch, or diametral pitch of cutter used. Then $P_n = \frac{\pi}{K}$, or transposing, $K = \frac{\pi}{P_n}$. If N = number of teeth in gear, the circumference of the pitch circle $= N \times H$, and $\frac{N H}{\pi}$ = pitch diameter $= D$. Hence,

$$D = \frac{N}{\pi} \times \frac{K}{\cos a} = \frac{N}{\pi \cos a} \times \frac{\pi}{P_n} = \frac{N}{P_n \cos a} \qquad (1)$$

In all cases where the shafts are parallel, the value of a is the same for both gears. The outside diameter of the spiral gear is found exactly as in spur gears, by adding $\frac{2}{P_n}$ to the pitch diameter. The derivation of formula $T = \frac{N}{\cos^3 a}$ was treated fully by H. W. Henes in MACHINERY, April, 1908, engineering edition, in an article entitled "Derivation of Formula for Determining Spur Gear Cutter Number for Spiral Gears."* A standard spur gear cutter is, of course, used in cutting spiral gears, but T, the number of teeth marked on it, will probably not be the actual number of teeth in the spiral gear to be cut, T depending, as the formula shows, on the spiral angle. In place of using this formula, the number of cutter, ranging from No. 8, cutting 12 to 13 teeth, to No. 1,



Figs. 5 and 6. Diagrams for Derivation of Formulas

cutting 135 teeth to a rack, can be found directly by a diagram contributed by Elmer G. Eberhardt, and published in the September, 1907, number of MACHINERY.† As to the lead of spiral, let Fig. 6 represent a spiral gear, where the oblique line is the path of the tooth unfolded. Then $L = \pi D \cot a$, in which L = lead of spiral, πD = pitch circumference, and a = spiral angle.

2. Shafts Parallel, Ratio Equal, and Center Distance Exact

The spiral angle a is found in terms of the number of teeth in each gear, normal diametral pitch, and pitch diameter, which latter is, of course, equal to the center distance.

From Formula (1) in Case (1) $D = \frac{N}{P_n \cos a}$, or $\cos a = \frac{N}{P_n \times D}$. The remaining formulas are found as in the first case.

3. Shafts Parallel, Ratio Unequal, and Center Distance Approximate

The formulas for this case are practically the same as for Case (1), and are derived in the same manner. The spiral angle is of the same value in both gears, as in all spiral gears with parallel shafts, but, of course, of a different direction (hand) in each gear.

4. Shafts Parallel, Ratio Unequal, and Center Distance Exact

In this case the sum of the two pitch diameters of the gears, or twice the center distance is $\frac{N}{P_n \cos a} + \frac{n}{P_n \cos a} = 2C$, from which, $\cos a = \frac{N + n}{2 P_n C}$.

N and n are the numbers of teeth in the respective gears, and C the center distance. The remaining eight formulas are similar to those of the other cases.

* * *

If you are looking for a perfect vacuum, examine the head of the man who "wasn't hired to do that."—*The Silent Partner.*

* See MACHINERY'S Reference Series No. 20, "Spiral Gearing," second edition, pages 21 to 24.

† See MACHINERY'S Reference Series No. 20, "Spiral Gearing," second edition, page 30; see also MACHINERY'S Data Sheet Series No. 6, "Bevel, Spiral and Worm Gearing," page 24.

COMPOSITION AND HEAT TREATMENT OF CARBON AND ALLOY STEELS*

While the steels and methods of heat treating them given in the following article have been prepared more especially for automobile construction, they also can be used in a large number of cases for manufacturing other products. It is obvious that there are more kinds of material specified than are likely to be used by any one manufacturer, but the number given represents a choice sufficient to cover all requirements.

Carbon Steel—0.15 Per Cent

Composition. Carbon, 0.08 to 0.18 per cent (0.15 per cent desired); manganese, 0.40 to 0.60 per cent (0.50 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent.

Characteristics and Uses. The source of this material is always the basic open hearth furnace. It is a material commonly used for seamless tubing, pressed steel frames, pressed steel brake-drums, sheet steel brake-bands and pressed steel parts of many varieties. It is soft and ductile, and will stand much deformation without cracking. This steel is weak, and in an annealed condition will have an elastic limit of about 30,000 pounds per square inch, with a very high reduction of area and elongation. When cold rolled, the elastic limit may be as high as 60,000 pounds per square inch, with but little reduction of area and elongation. This relatively high elastic limit can only be obtained in light or small sections. This material should not be used for such parts as are to be machined, as it will tear badly when turning, threading or broaching.

Heat Treatment. This steel is not much benefited in strength by heat treatment, but is increased somewhat in toughness. It is possible to heat treat this steel, and thus make it easier to machine than in the annealed state. Forgings may be made from it, but are not desirable and should be avoided. The heat treatment which will produce stiffness, is to heat to 1500 degrees F. and quench in oil or water, no drawing being necessary.

Carbon Steel—0.20 Per Cent

Composition. Carbon, 0.15 to 0.25 per cent (0.20 per cent desired); manganese, 0.50 to 0.80 per cent (0.65 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent.

Characteristics and Uses. The natural source of supply for this material is the basic open hearth process. It is intended primarily for casehardening purposes, and can be easily forged and machined. It is not a very strong material. This steel is soft and ductile, having an elastic limit in the annealed condition of about 35,000 pounds per square inch. It may be drawn into tubes and cold rolled, and as a matter of fact, makes a better frame because of the slightly higher carbon content and resulting stiffness. The increased carbon content has no detrimental effect so far as working it is concerned, and it is only under the most difficult forming operations that it will crack.

Heat Treatment. This steel is little affected by heat treatment, as far as strength is concerned, but heat treating after forging, does cause a desirable refinement of the grain, and the toughness is materially increased. A simple quenching operation from about 1500 degrees F. in oil is generally used. The casehardening treatment is the most important for this steel, the character of the treatment depending upon the importance of the parts to be treated—their shape and size.

Heat treatment after forging or machining:

1. Carbonize at a temperature between 1600 and 1750 degrees F. (1650 to 1700 degrees F. desired). 2. Cool slowly in the carbonizing mixture. 3. Reheat, 1500 to 1550 degrees F. 4. Quench. 5. Reheat, 1400 to 1450 degrees F. 6. Quench. 7. Draw in oil at a temperature varying from 300 to 450 degrees F.—the temperature depending on the degree of hardness desired.

* Abstract of the second report made by the Iron and Steel Division of the Society of Automobile Engineers' Standards Committee at the Summer meeting in Dayton, Ohio, June 15-17, 1911.

Carbon Steel—0.30 Per Cent

Composition. Carbon, 0.25 to 0.35 per cent (0.30 per cent desired); manganese, 0.50 to 0.80 per cent (0.65 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent.

Characteristics and Uses. The natural source of supply of this material is the basic open hearth process, and it is primarily used as a structural steel. It forges well, machines well and responds to heat treatment in the matter of strength as well as toughness. That is to say, intelligent heat treatment will produce a marked increase in the elastic limit. It may be used for all forgings, such as axles, driving-shafts and other structural parts. In the annealed condition the elastic limit is about 45,000 pounds per square inch, with ample elongation and reduction of area.

Heat Treatment. As strength and toughness are of prime importance in this steel, the heat treatment must be modified in accordance with the experience of the individual user. The steel should be heat treated in all cases where reliability is important. Machining may precede the heat treatment of this steel. If the highest strength is required strong quenching solutions must be employed, for example, brine. If quenched in brine, the elastic limit will be correspondingly high, and the steel correspondingly hard and difficult to machine. On the other hand, if a moderately high elastic limit is all that is desired, an oil quench will suffice, and machining may follow without difficulty.

Carbon Steel—0.45 Per Cent

Composition. Carbon, 0.40 to 0.50 per cent (0.45 per cent desired); manganese, 0.50 to 0.80 per cent (0.65 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent.

Characteristics and Uses. The natural sources of supply of this steel are basic or acid open hearth, and crucible or electric furnace, the most common being the basic open hearth. This steel possesses greater strength for structural purposes than 0.30 carbon steel. Its uses, however, are more limited and are confined in a general way to such parts as demand a high degree of strength and a relatively low degree of toughness. With proper heat treatment the fatigue resisting qualities are very high. The principal uses for this steel are: crankshafts, driving-shafts, propeller-shafts and transmission gears. It is not hard enough, however, without case-hardening, and is not tough enough with case-hardening to make safe transmission gears, and should not be used for casehardened parts, except in an emergency. In the annealed condition this steel should have an elastic limit of about 50,000 pounds per square inch, and after heat treating, the elastic limit may be nearly doubled.

Heat treatment. After forging or machining: 1. Heat to 1550 degrees F. 2. Quench. 3. Anneal by heating to 1450 degrees F. 4. Cool slowly in furnace, in lime or soft coal. 5. Reheat, 1400 to 1500 degrees F. 6. Quench. 7. Heat, 800 to 1000 degrees F. and cool slowly.

Carbon Steel—0.80 Per Cent

Composition. Carbon, 0.75 to 0.90 per cent (0.80 per cent desired); manganese, 0.25 to 0.50 per cent (0.35 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.035 per cent; sulphur, not over 0.035 per cent.

Characteristics and Uses. This steel is used principally for springs, and generally speaking for springs of light section. Its sources of supply may be the open hearth, crucible or elastic furnace.

Heat Treatment. It must be understood that the higher the drawing temperature, the lower will be the elastic limit of the material. On the other hand, if the material be drawn to too low a temperature it will be brittle. The hardening and drawing of springs, that is the heat treatment of them, is as a rule, in the hands of the spring maker, but for small coil springs the following treatment is recommended: 1. Coil. 2. Heat, 1400 to 1500 degrees F. 3. Quench in oil. 4. Reheat, 400 to 500 or 600 degrees F. in accordance with the degree desired, and cool slowly.

Carbon Steel—0.95 Per Cent

Composition. Carbon, 0.90 to 1.05 per cent (0.95 per cent desired); manganese, 0.25 to 0.50 per cent (0.35 per cent

desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.035 per cent; sulphur, not over 0.035 per cent.

Characteristics and Uses. This steel is obtained from the same sources as 0.80 carbon steel and is used principally for springs.

Heat Treatment. Substantially the same remarks apply to this steel as to 0.80 carbon steel. The heat treatment may be reduced slightly because of the increased carbon content, and possibly the drawing temperature will be different.

Nickel Steel—0.20 Carbon, 3 1-2 Per Cent Nickel

Composition. Carbon, 0.15 to 0.25 per cent (0.20 per cent desired); manganese, 0.50 to 0.80 per cent (0.65 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 3.25 to 3.75 per cent (3.50 per cent desired).

Characteristics and Uses. This steel is primarily intended for casehardening. The carbon content is relatively low, which means that the interior metal of a casehardened piece will be tough. The elastic limit in the annealed condition is 45,000 pounds per square inch, with good reduction and elongation. It will respond well to heat treatment, and the elastic limit will be increased to about 60,000 or 70,000 pounds per square inch, with a better reduction of area than in the annealed state. The principal uses of this steel are for casehardened gears, both for the belt driven and transmission system, and for such other casehardened parts as demand a very tough, strong interior with a hardened exterior.

Heat Treatment. The casehardening sequence may be varied considerably, but as a rule those parts which require the use of nickel steel generally require the best type of casehardening.

After forging or machining: 1. Carbonize at a temperature between 1600 and 1750 degrees F. (1650 to 1700 degrees F. desired). 2. Cool slowly in the carbonizing material. 3. Reheat, 1450 to 1525 degrees F. 4. Quench. 5. Reheat, 1400 to 1450 degrees F. 6. Quench. 7. Reheat to a temperature from 250 to 500 degrees F. (in accordance with the necessities of the case) and cool slowly.

The second quench (operation 6) must be conducted at the lowest possible temperature at which the material will harden. It will be found that this is sometimes as low as 1300 degrees F. It will be found possible in some cases to omit the final drawing (operation 7) entirely, but for parts of the highest importance this operation should be followed as a safe-guard. Parts of intricate shape comprising sudden changes of thickness, sharp corners and the like should always be drawn, in order to relieve internal strains.

Nickel Steel—0.30 Carbon, 3 1-2 Per Cent Nickel

Composition. Carbon, 0.25 to 0.35 per cent (0.30 per cent desired); manganese, 0.50 to 0.80 per cent (0.65 per cent desired); silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 3.25 to 3.75 per cent (3.50 per cent desired).

Characteristics and Uses. This steel is primarily intended for heat treating, and is used for structural parts where much strength and toughness are desired; such parts as axles, spindles, crank-shafts, driving-shafts and transmission-shafts. The elastic limit in the annealed condition is about 55,000 pounds per square inch. By heat treatment this may be increased to 160,000 pounds per square inch, the ductility at this point being satisfactory, and a reduction of area of at least 45 per cent being obtainable. The wide variation in the elastic limit is obtained by the use of different quenching mediums—brine and oil—and a difference in the drawing temperatures.

Heat Treatment. After forging and machining: 1. Heat, 1450 to 1500 degrees F. 2. Quench. 3. Heat, 600 to 1200 degrees F. and cool slowly.

A higher refinement of this treatment is: After forging and machining: 1. Heat, 1450 to 1500 degrees F. 2. Quench. 3. Reheat, 1350 to 1400 degrees F. 4. Quench. 5. Heat, 600 to 1200 degrees F. and cool slowly.

By the proper regulation of the quench and drawing tempertures, a wide range of physical characteristics may be obtained. The thickness of the mass treated, the volume and temperature of the quenching medium and other details peculiar to most hardening plants, must be recognized in order to get intelligent and desirable results. This material may be casehardened, but it contains a rather high carbon content for this purpose. The lower ranges of carbon—0.25 per cent—are satisfactory, but the upper ranges—in the neighborhood of 0.35 per cent approach the danger point, and steel of this carbon content must be correspondingly carefully hardened.

Chrome-nickel Steel—0.15 Carbon

Composition. Carbon, 0.10 to 0.20 per cent (0.15 per cent desired); manganese, 0.40 to 0.60 per cent (0.50 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 1.50 to 2.00 per cent (1.75 per cent desired); chromium, 0.50 to 1.00 per cent (0.75 per cent desired).

Characteristics and Uses. This steel is primarily intended for alloy steel frames, and for heat treatment when so used. It may be used for other purposes, such as structural parts or for casehardened parts by simply modifying the heat treatments, but as this composition is not intended for such use, no further discussion will be given.

Heat Treatment, for frames after forming. 1. Heat, 1400 to 1450 degrees F. 2. Quench. 3. Heat, 1000 to 1200 degrees F. and cool slowly. The exact temperatures for operations 2 and 3 must be determined experimentally, being somewhat dependent upon the thickness of the stock, temperature of the quenching medium and the design of the part. Generally speaking, thin sections, such as frames, respond readily to quenching operations and must be handled with corresponding care.

Chrome-nickel Steel—0.20 Carbon

Composition. Carbon, 0.15 to 0.25 per cent (0.20 per cent desired); manganese, 0.30 to 0.50 per cent (0.40 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 3.25 to 3.75 per cent (3.50 per cent desired); chromium, 1.25 to 1.75 per cent (1.50 per cent desired).

Characteristics and Uses. This steel is intended primarily for casehardened parts. The treatment may be so varied as to render it possible to use this steel for many structural parts. Its strength in an annealed condition is not of much importance, as this alloy, as well as others, offers no material advantage over carbon steels unless it is heat treated.

Heat Treatment. The heat treatment should be modified according to the results obtained by practical experiment. An elastic limit of 120,000 pounds per square inch is possible, with a large measure of reduction of area and elongation.

After forging and machining: 1. Carbonize at a temperature between 1600 and 1750 degrees F. (1650 to 1700 degrees F. desired). 2. Cool slowly in the carbonizing mixture. 3. Reheat, 1400 to 1500 degrees F. 4. Quench. 5. Reheat, 1300 to 1400 degrees F. 6. Quench. 7. Heat, 250 to 500 degrees F. and cool slowly.

The heating for the second quench (operation 5) should be carried out at the lowest possible temperature at which sufficient hardness may be obtained.

Chrome-nickel Steel—0.30 Carbon

Composition. Carbon, 0.25 to 0.35 per cent (0.30 per cent desired); manganese, 0.30 to 0.50 per cent (0.40 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over, 0.04 per cent; nickel, 3.25 to 3.75 per cent (3.50 per cent desired); chromium, 1.25 to 1.75 per cent (1.50 per cent desired).

Characteristics and Uses. This grade of chrome-nickel steel is intended largely for structural parts of the most important character; parts requiring this high grade of steel must be heat treated, otherwise there is no gain commensurate with the increased cost of the steel. It is suitable for crankshafts, axles, spindles, driving-shafts, transmission-shafts and, in fact, the most important structural parts of an automobile. The elastic limit in the annealed condition is of no importance, as this steel should not be used in the annealed state. The elastic limit after heat treating may be as high as 175,000 pounds per square inch, with a generous reduction of area and elongation.

Heat Treatment. After forging and machining: 1. Heat, 1450 to 1500 degrees F. 2. Quench. 3. Reheat to a temperature between 500 and 1250 degrees F. and cool slowly.

A higher refinement of this treatment is, after forging: 1. Heat, 1450 to 1500 degrees F. 2. Quench. 3. Reheat to 1400 degrees F. 4. Quench. 5. Reheat to a temperature between 500 and 1250 degrees F. and cool slowly.

The temperatures when treating and annealing should be controlled by a pyrometer.

The lower the temperature at which the proper response to treatment is obtained, the better will be the results. At the same time, if a sufficient temperature is not used, there will be an incomplete or unsatisfactory response. This steel is not intended for casehardening, but may be so treated in an emergency. If casehardening is attempted the highest degree of care must be exercised.

Chrome-nickel Steel—0.45 Carbon

Composition. Carbon, 0.40 to 0.50 per cent (0.45 per cent desired); manganese, 0.40 to 0.60 per cent (0.50 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 1.50 to 2.00 per cent (1.75 per cent desired); chromium, 0.80 to 1.20 per cent (1.00 per cent desired).

Characteristics and Uses. This steel is used mostly for gears where extreme strength is necessary. The carbon content is sufficiently high to cause the material, in the presence of chromium and nickel, to become sufficiently hard to make a good gear when quenched, without casehardening. The characteristics of this steel in an annealed condition are unimportant, as it should not be used in that condition. The heat treatment produces as an elastic limit as high as 200,000 pounds per square inch, with good reduction of area and elongation. This steel is difficult to forge, and during the forging operation it should be kept at a thoroughly plastic heat, and not hammered after the temperature drops to ordinary forging temperatures, as cracking is liable to result; the steel also becomes hard and forges with great difficulty. On the other hand, too high a temperature is not advisable, as the steel becomes red-short and breaks. Generally speaking, the higher the carbon content of chrome-nickel steel, the more this characteristic is found to be true.

Heat Treatment. To heat treat this steel for gears after forging: 1. Heat to 1500 degrees F. plus or minus 25 degrees F. 2. Quench. 3. Reheat, 1400 to 1450 degrees F. (Hold at this temperature one-half hour, to ensure thorough heating.) 4. Cool slowly. 5. Reheat, 1450 to 1500 degrees F. 6. Quench. 7. Reheat, 250 to 550 degrees F. and cool slowly.

This steel cannot be machined unless thoroughly annealed. The final drawing operation must be conducted to a heat which will produce the proper degree of hardness. The Brinell hardness test for a gear is between 430 and 470, the corresponding Shore hardness number being from 75 to 85. This steel should not be casehardened.

Chrome-vanadium Steel—0.20 Carbon

Composition. Carbon, 0.15 to 0.25 per cent (0.20 per cent desired); manganese, 0.40 to 0.70 per cent (0.50 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; chromium, 0.80 to 1.10 per cent (0.90 per cent desired); vanadium, not less than 0.10 per cent (0.18 per cent desired).

Characteristics and Uses. This steel is primarily for casehardening, and is used for the best casehardened parts, such as shafts, gears, etc. The physical characteristics of this steel, annealed, are unimportant.

Heat Treatment. This material will respond somewhat to heat treatment, and be considerably benefited thereby. Its proper use is for casehardening, however, and the following treatment is recommended:

After forging and machining: 1. Carbonize at a temperature between 1600 and 1750 degrees F. (1650 to 1700 degrees F. desired). 2. Cool slowly in the carbonizing mixture. 3. Reheat, 1600 to 1700 degrees F. 4. Quench. 5. Reheat, 1300 to 1400 degrees F. 6. Quench. 7. Reheat, 250 to 500 degrees F. and cool slowly.

The high initial quenching temperature of this steel is noteworthy—that is, something a little over 1600 degrees F. This differs from the other steels referred to, and also from the characteristics of chrome-vanadium steel. The heating for the second quench (operation 5) should be conducted at the lowest possible temperature that will harden the exterior carbonized surface. Practical experiments will develop the best temperature for local conditions in any hardening-room.

Chrome-vanadium Steel—0.30 Carbon

Composition. Carbon, 0.25 to 0.35 per cent (0.30 per cent desired); manganese, 0.40 to 0.70 per cent (0.50 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; chromium, 0.80 to 1.10 per cent (0.90 per cent desired); vanadium, not less than 0.10 (0.18 per cent desired).

Characteristics and Uses. This steel is used for structural purposes, and for crank-shafts, driving-shafts, axles, etc. The physical characteristics in the annealed condition are unimportant, as the steel should not be used in that condition—not that it is unsafe, but because there will be no gain commensurate with the increased cost of the material.

Heat Treatment. After forging and machining: 1. Heat, 1600 to 1700 degrees F. 2. Quench. 3. Reheat to a temperature between 500 and 1300 degrees F. and cool slowly.

The elastic limit after heat treatment may be from 60,000 to 150,000 pounds per square inch, with good toughness as represented by the reduction of area and elongation. This steel may be casehardened, but if so treated it must be handled with care on account of the relatively high carbon content.

Chrome-vanadium Steel—0.45 Carbon

Composition. Carbon, 0.40 to 0.50 per cent (0.45 per cent desired); manganese, 0.60 to 0.90 per cent (0.75 per cent desired); silicon, 0.10 to 0.30 per cent; phosphorus, not over 0.035 per cent; sulphur, not over 0.035 per cent; chromium, 1.00 to 1.30 per cent (1.20 per cent desired); vanadium, not less than 0.10 per cent (0.18 per cent desired).

Characteristics and Uses. This steel contains sufficient carbon in combination with vanadium to harden when quenched at a proper temperature. The elastic limit after suitable treatment may be carried as high as 200,000 pounds per square inch, with a reduction of area great enough to indicate good toughness. This steel may be used for structural parts where exceedingly great strength is required.

Heat Treatment. The information given relative to the heat treatment of 0.30 carbon, chrome-vanadium steel also applies to this steel. The drawing temperature must be considerably modified to produce proper stiffness. For gears this steel must be annealed after forging. The heat treatment is as follows: 1. Heat to 1600 degrees F. 2. Quench. 3. Reheat to 1450 degrees. 4. Cool slowly. 5. Reheat, 1600 to 1650 degrees F. 6. Quench. 7. Reheat, 350 to 550 degrees F., and cool slowly.

This last drawing operation (7) must be modified to obtain any desired hardness.

Silico-manganese Steel

Composition. Carbon, 0.45 to 0.55 per cent (0.50 per cent desired); manganese, 0.60 to 0.80 per cent (0.70 per cent desired); silicon, 1.90 to 2.20 per cent (2.00 per cent desired); phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent.

Characteristics and Uses. This steel is intended for structural parts, springs, gears, etc. It should not be used without heat treatment. The physical characteristics in the heat-treated condition are similar to those of the other alloyed steels specified, the elastic limit being under control, and ranging from 60,000 to 175,000 pounds per square inch, with good reduction and elongation of area.

Heat Treatment. For structural parts the heat treatment should be as follows:

After forging and machining: 1. Heat, 1650 to 1750 degrees F. 2. Quench. 3. Reheat to a temperature between 600 and 1400 degrees F. and cool slowly.

Suitable temperatures for a given thickness of piece, and the character of the quenching medium must be determined experimentally. When used for springs, this material may be treated as previously explained, with proper modifications as to the drawing temperature, with the probability that 800 degrees F. as a drawing temperature will give about the proper characteristics.

Common Screw Stock

Composition. Carbon, 0.08 to 0.25 per cent; manganese, 0.30 to 0.80 per cent; phosphorus, not over 0.16 per cent; sulphur, 0.05 to 0.15 per cent.

Characteristics and Uses. This steel may be made by any process. There are two types of screw stock commonly found in the market, and the composition given covers these. The controlling element in one type is phosphorus, which is commonly found between 0.10 and 0.20 per cent. The controlling element in the other type is sulphur, which is commonly found between 0.07 and 0.15 per cent. The ordinary screw stock machines easily and is a cheap steel, lacking strength and toughness. It is an unsafe steel and must not be used for vital parts of an automobile.

Heat Treatment. Screws made from these materials, from hot-rolled bars, should be heat treated and not used in a rolled or annealed condition. Screws made from cold-rolled bars are much stronger than if in a hot-rolled, annealed condition. But the best results from both types of steel may be obtained if heat treated. Heat treatment after machining produces the strongest screw. If machined after heat treatment, the grain of the material is, in effect, nicked by the thread and thereby weakened. The heat treatment for screws is as follows:

After machining: 1. Heat to 1500 degrees. 2. Quench. 3. Reheat from 600 to 1300 degrees F. and cool slowly.

Low Alloy Steel

Composition. Carbon, as desired; manganese, 0.50 to 0.80 per cent; silicon, not over 0.20 per cent; phosphorus, not over 0.04 per cent; sulphur, not over 0.04 per cent; nickel, 0.90 to 1.20 per cent; chromium, 0.15 to 0.40 per cent.

Characteristics and Uses. This steel is made of ores containing chromium and nickel. Steels made from such ores may be referred to as natural alloy steels. At the same time other steels closely duplicating them in analysis are made by the addition of chromium- and nickel-containing materials to an otherwise simple steel. As found in the market these steels contain about 1.00 per cent of nickel and from 0.15 to 0.40 per cent of chromium. Of such composition, there is a material gain in strength and toughness, as the result of heat treatment. These steels are obtainable in any desired carbon from 0.10 to 1.00 per cent. At a slight increase in cost, say, from $3.00 to $5.00 per ton in the billet form, these steels may be obtained containing from 0.30 to 0.60 per cent chromium, which composition results in a very decided gain in physical characteristics.

Heat Treatment. The natural alloy steels respond to the casehardened treatment better than the plain carbon steels and the nickel steels of similar carbon content. For example, a 0.20 carbon, natural alloy steel makes an excellent gear when properly carbonized and heat treated in accordance with the heat treatment given for 0.20 carbon, 3½ per cent nickel steel. For structural purposes 0.30 carbon or even 0.40 carbon steel may be used when properly treated.

Quenching Mediums

Brine, water, oil and many special compounds are used as quenching mediums; brine produces the sharpest results, but is severe, and has a greater tendency to warp the parts. It produces a higher elastic limit than either water or oil. Water is intermediate between brine and oil, and frequently may be used to advantage for hardening parts of suitable section and thickness. Its tendency to warp the parts is not as great as that of brine, nor can so high an elastic limit be obtained with it. Fish oil, cotton seed and lard oil are best for quenching purposes. These are the mildest of the quenching mediums, and should be used when it is found possible to obtain the desired results by their use. All reference to quenching in the foregoing treatment means oil unless otherwise stated. If found by experiment that oil will not produce the desired results, then water should be tried, or even brine. Nearly all casehardened parts may be successfully hardened in oil, as it exhibits less tendency to warp the parts than any other of the quenching mediums mentioned.

Summary and General Remarks

In the foregoing article the tensile strength per square inch indicates the strength of the steel in a rod having one square inch area of cross-section. This standard has been adopted so that no matter what the size of the test-specimen may be, the results are calculated on a square inch basis. The elastic limit as generally referred to in engineering practice is not the true elastic limit, except in those instances where close-reading extensometers are used. The elastic limit usually referred to is that obtained by either the drop of the beam of the testing machine or by means of dividers which indicate when the test-specimen begins to stretch, as visibly noted.

It is to be understood in connection with the foregoing that the elastic limit is that point at which, if the load on the steel specimen be released, the specimen will return to its original length before it was placed under the tension test, and beyond which, if the load be released, the specimen will not return to its original length. The elastic limit therefore is really necessary to use in figuring all strains and stresses for structural purposes. The reduction of area, is the measured amount (in per cent) that a test-specimen reduces in size at the point of fracture. This factor is valuable because it shows the condition of the steel in the specimen. For instance, a coarse-grained overheated steel or an under-worked steel shows a low percentage of reduction of area and is, therefore, to be avoided. On the other hand, a steel well hammered or rolled or heat-treated shows a high percentage of reduction of area as the result of a very fine grain.

Elongation represents the ductility and softness of material. A considerable degree of elongation is required in order that there may be nothing abnormal about the material being tested.

Endurance is conveniently studied by means of a so-called "alternate stress" or "endurance" machine, and is to be understood so when mentioned in the foregoing. It is a fact that tensile tests giving elastic limit, maximum strength, reduction of area and elongation, indicate the probable endurance of the steel. At the same time the endurance of the steel is not always proportional to the increase of elastic limit or the increase of elongation and reduction of area. Consequently, the endurance machine is the best method of studying the real effect of heat treatment on materials.

Natural conditions in a steel mean little. They are supposed to represent the condition of the steel after ordinary hot rolling or forging operations. Steel in such a condition may be said to be either good or bad, depending largely upon the accidental sequence of operations and the method of carrying them out. This condition might well be called an accidental rather than a natural condition. It is not a good term to use and should be avoided. Steel in a natural condition after annealing is uniform and safe, even if not as strong or as tough as it would be after a suitable heat treatment. Annealing consists of heating to a temperature above the critical point, and cooling slowly; drawing consists of heating to some point below the critical point and cooling slowly; heat treating consists of a sequence of quenching and slow cooling operations, and quenching and suddenly cooling the steel in any liquid or in air.

* * *

HIGH-SPEED STEEL WELDED ARMOR PLATE

About three years ago W. S. Simpson discovered that plates of high-speed carbon steel, with a thin plate of copper between them, could be welded with a flux consisting of a stiff mixture of carbon (lamp black), brown sugar and water when heated to a temperature of 2000 degrees F. The copper melts and enters into solution with the steel and forms a perfect weld which will not part nor split. The copper appears to increase the tenacity of the steel so that the weld is even stronger than the solid steel. The process is being developed in England for the manufacture of composite armor plates consisting of a tough steel back plate faced with hardened high-speed steel. A plate consisting of 4-inch carbon toughened steel, and 2-inch hardened high-speed steel successfully resisted attack with 6-inch projectiles. A comparison of the process with the Harvey and Krupp processes of face hardening armor plate shows its advantages. The carbonization of a face-hardened plate rarely penetrates more than ⅞ inch, and while Krupp armor is about 50 per cent superior to the best Harveyized plate, the Simpson process plate has 75 per cent greater resistance.

POWER FORGING AND STEAM HYDRAULIC FORGING PRESSES*

The paper abstracted in the following deals principally with the most modern methods of producing forgings, but contains also a brief review of the various methods for power forging employed. It is a fact, well-known to all, that the power of the hand hammer is not derived from its weight alone, but from weight combined with velocity, and the same is true of the sledge and of all kinds of drop hammers, whether lifted by friction, water power, or steam. The power of a drop hammer depends solely upon the mass of the hammer and its lift, whereas certain kinds of hammers operated by steam or compressed air obtain additional power by increasing the acceleration beyond that caused by gravity alone.

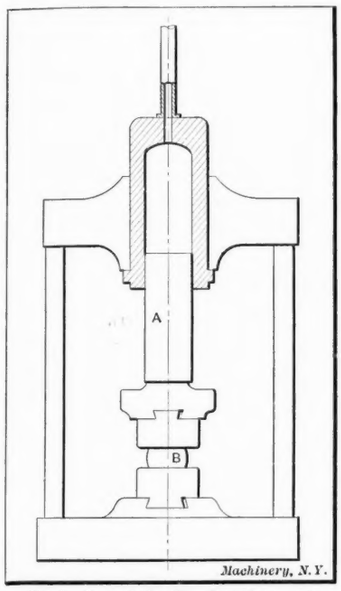


Fig. 1. One of the Simplest Types of Forging Presses

While the steam hammer is comparatively old, the modern type of forging press illustrated diagrammatically in Fig. 1 is a comparatively recent development. A plunger *A* is forced by hydraulic pressure against the forging *B*, thus exerting a steady pressure instead of a blow. In the course of events this type of forging press began to supplant large steam hammers everywhere, whereas the small hammer, operated by steam or compressed air, has held its own for small work. In the author's opinion, the logical reason for this fact is the following: Small pieces cool quickly and, as a rule, require a finer surface finish than is demanded in large forgings. Since the hammer strikes a blow, the force of the impact increases as the forging cools, so that work is done on the surface of the forging, even when it is quite cool. The press, on the other hand, would be powerless to do any work on the cold piece, unless the anvil surface was reduced very much. Thus the hammer will probably always be used for small work and for making tools, because tool steel must not be heated as much as machinery steel or wrought iron.

The very features which make the hammer desirable for small work make it undesirable for large work. The hammer acts upon the surface of the material, driving the surface over the core without compressing the latter, as shown in Fig. 2. The press, on the other hand, exerts a continuous pressure, which forces the semi-fluid material of the forging to flow under compression, as shown in Fig. 3, which process tends to increase the density of the material. It is thus evident that from the standpoint of improving the quality of the material in forgings, the press is superior to the hammer, and it would be considered even more useful if, under equal conditions, it used less steam than a hammer would consume.

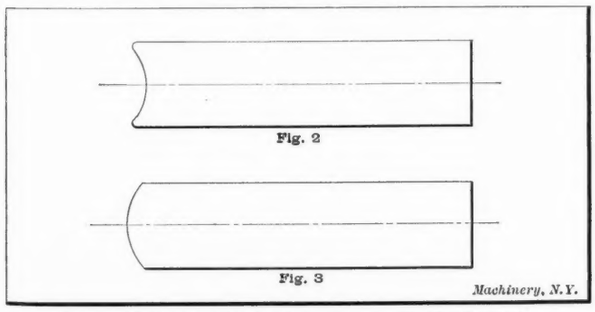


Fig. 2. Effect of Forging by Hammering. Fig. 3 Effect of Forging by Pressure

To investigate the comparative steam consumption, a concrete case will be assumed. Let the dimensions of a hammer with live steam above the piston be as follows: (These dimensions were converted from the metric dimensions, which accounts for the odd sizes.)

Weight of falling parts, $P = 5$ long-tons,
Diameter of steam cylinder = 27½ inches,
Stroke of piston = 79 inches,
Initial steam pressure = 107 pounds per square inch,
Mean effective pressure = 71 pounds per square inch,
Face area of anvil = 186 square inches

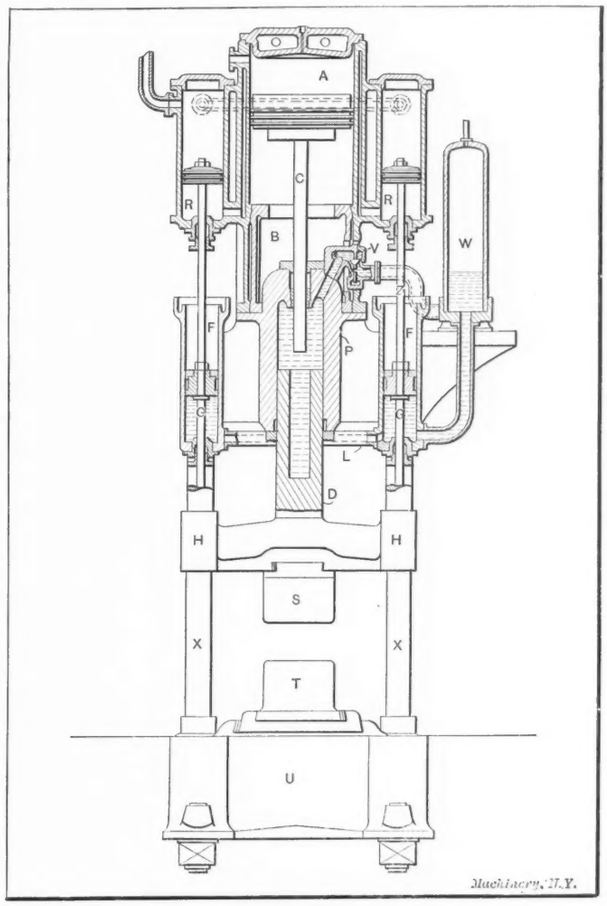


Fig. 4. Steam-hydraulic Forging Press

Then we find:

1. Mean effective accelerating force (P_2) due to steam pressure =

$$\frac{\pi}{4} \times 27.5^2 \times 71 = 42{,}000 \text{ pounds.}$$

2. Acceleration provided by P and P_2 =

$$\frac{(42{,}000 + 11{,}200)\ 32.2}{11{,}200} = 155 \text{ feet per second, approximately.}$$

3. Velocity (V) of moving parts at end of stroke =
$\sqrt{2 \times \text{acceleration} \times \text{stroke}} = 45$ feet per second.

4. Kenetic energy stored up in moving parts =

$$\frac{53{,}200 \times 79}{12} = 350{,}000 \text{ foot-pounds.}$$

For hammers of this size and correct temperature of forging, it may be assumed that the moving masses are brought to rest within a space of 1⅝ inch. Basing the retardation of the moving parts upon this distance, the average retarding force is found to be 2,580,000 pounds or, approximately, 1200 long-tons. This figure may be termed "the force of the blow," and will be used in the following for comparison with the conditions in a press. This force was based upon a retardation

* Abstract of paper by Barthold Gerdau, of Düsseldorf, Germany, and George Mesta, of Pittsburg, Pa., read before the American Society of Mechanical Engineers, at the May, 1911, meeting in Pittsburg, Pa.

space of 1⅝ inch. It should not be assumed that all of this space is utilized for compressing the forging. The elasticity of the foundations absorb a considerable amount of the work of the blow. A correct mathematical treatise of these losses meets with great difficulties. From the experience of the authors, it appears that almost one-third of the work is lost in vibrations, so that only about one inch of useful compression of the forging results.

Since it is intended to investigate the relative economy of different methods of forging, the steam consumption per working stroke of the hammer in question will now be computed. Steam is needed for the lifting and for the down-stroke. The steam for the up-stroke may be figured approximately from the equation that pressure multiplied by change of volume equals work done. Thus, cubic feet of steam required for up-stroke =

$$\frac{11{,}200 \times \frac{79}{12}}{144 \times 107} = 4.8 \text{ cubic feet} = 1.3 \text{ pounds.}$$

For the down-stroke a cylinder full of steam at 71 pounds per square inch pressure may be taken, which will be sufficiently close for this purpose. Thus, the volume of steam per down-stroke =

$$\frac{\frac{\pi}{4} \times 27.5^2 \times 79}{144 \times 12} = 27 \text{ cubic feet} = 5.4 \text{ pounds.}$$

The steam consumption of one cycle then equals 6.7 pounds.

This steam consumption is based upon correct operation of the hammer, which, however, is seldom realized if the operator neglects to close the throttle at the instant the hammer touches the forging, because in that case the pressure in the cylinder may rise to boiler pressure. If the hammer is used to strike light blows, full strokes may be made, using the hammer principally as gravity drop, or short strokes may be made with live steam on top. In either case the steam consumption per unit of work done is enormously increased. The great number of combinations possible forbids giving figures.

Turning to the steam consumption of the press, we find that conditions are not so simple. It will be remembered from Fig. 1 that the press is operated by water under pressure. The steam consumption then depends first upon the method of producing the water pressure and second upon the losses of water pressure between its production and its application to the press plunger. Before the intended computation can be made, it is evidently necessary to review the various types of presses on the market. Two general types of presses exist: (1) The so-called purely hydraulic presses whose pressure water is furnished by separate pumping engines. (2) The so-called steam-hydraulic presses in which water under pressure is generated in a steam intensifier.

The general type mentioned under (1) is best illustrated by Fig. 1; the pipe at the top of the cylinder is connected either directly or by means of a hydraulic accumulator to a high-pressure pump which may be either direct-acting or of the crank-flywheel type.

The type mentioned under (2) is shown diagrammatically in Fig. 4. The press consists of a heavy base *U* and four uprights *X*, supporting the hydraulic and steam cylinders above. *S* and *T* are the dies, the upper one being carried by the crosshead *H*. This crosshead is moved into position for forging by the use of the steam cylinders *R*. Pressure for forging is obtained by admission of steam into the top of cylinder *A*, which moves the piston downward and forces rod *C* into the hydraulic cylinder *P*. This action again causes the plunger *D* to move downward, carrying with it the crosshead and the upper die. The effect is that of a steam-actuated intensifier. Hydraulic cylinder *P*, balancing cylinders *F*, and about one-third of air chamber *W*, are filled with water. Air pressure of about 100 pounds per square inch is pumped into air chamber *W*, which is sufficient to move piston rod *C* with its piston to the top of the cylinder. The areas of plunger *D* and cylinders *F* are equal, so that the downward force on plunger *D*, due to the air pressure on the water, is counterbalanced by cylinders *F*. By opening check valve *V* in the connection between air chamber *W* and hydraulic cylinder *P*, thus allowing water to flow from the hydraulic cylinder to the air chamber, and admitting steam to cylinders *R*, the crosshead can be raised to any position and similarly it can be lowered.

Referring to type (1) it is found that the pumps commonly work against a pressure of 4300 pounds per square inch, which is maintained by an accumulator. Unfortunately, the process of forging does not always require all of this pressure, but on the average only about 50 to 60 per cent of this amount, the remaining 40 to 50 per cent being lost in the controlling valve. It might appear that it would be more economical to let the pump work directly against the press without an accumulator

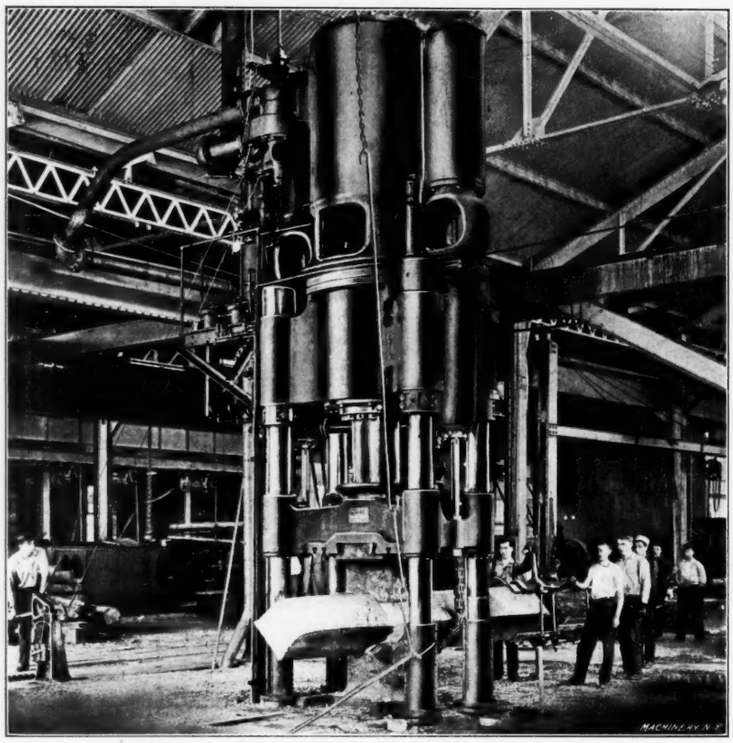


Fig. 5. Eight-hundred Ton Four-column Steam-hydraulic Forging Press

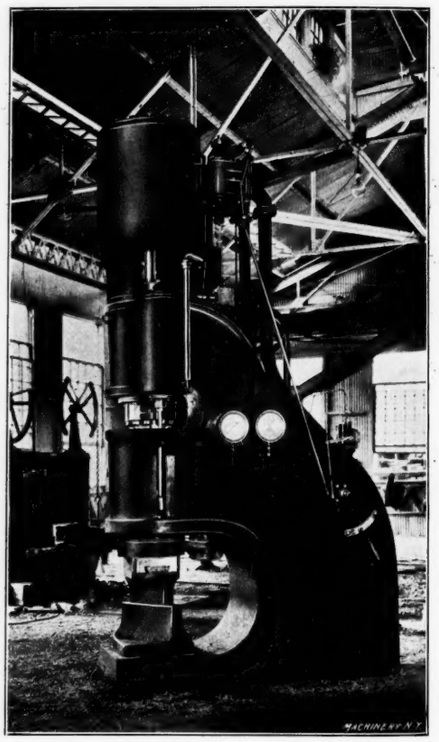


Fig. 6. Two-hundred Ton Forging Press

and even without intermediate controlling valves, but this scheme is too ideal to be practical. It has been found necessary to provide controlling valves, by-pass valves, throttling governors and other means for regulating the speed and power of the press. Nevertheless, this type of press has one advantage, namely, that it can make a continuous full-pressure stroke of the maximum length for which the press was built. For this reason this type is most advantageous for drawing operations —for instance, the drawing of tubes, etc.

Taking up type (2) as illustrated by Fig. 4, it has already been mentioned that the pressure is generated by a direct-acting intensifier which is similar in its action to a direct-acting pump. While at first thought it might appear that the direct-acting intensifier, which necessarily has to maintain an almost constant steam pressure throughout the stroke, would be inferior to a high-class compound crank and flywheel pump, experience has taught that the opposite is the case, the reason being that the work is intermittent and requires a continually varying amount of power.

After these explanations we are ready to take up the computation of the steam consumption of a press for the same work which formed the basis for a similar calculation for the steam hammer. From what has been said it is evident that the type of pump, the conditions under which it works, the proper balancing of the accumulator pressure with regard to the work and other factors, affect the steam consumption. Therefore the following figures should be considered only as an attempt to solve the problem.

The effective work of the hammer was about 240,000 foot-pounds per working stroke. Basing the press on the same work and taking the efficiency of the transmission pipe as 90 per cent, the pressure drop in pump ports as 10 per cent, and the efficiency of the pump as 75 per cent, the work actually to be done in the pump cylinder is 395,000 foot-pounds. Let the pump be driven by a steam engine whose steam consumption is 32 pounds per horsepower per hour on account of the intermittent working; then the steam required for the equivalent work is

$$\frac{395{,}000 \times 32}{33{,}000 \times 60} = 6.3 \text{ pounds.}$$

This shows that the purely hydraulic press is slightly more economical than the steam hammer.

Matters are a great deal simpler for the direct-acting steam-hydraulic press. Basing the calculation upon the fact that pressure times change of volume equals work, and assuming a steam pressure of 150 pounds per square inch gage, we find the necessary volume of steam to be

$$\frac{240{,}000}{150 \times 144} = 11 \text{ cubic feet, or } 3.7 \text{ pounds of steam.}$$

For the sake of simplicity, friction of pistons has been neglected in all cases. This last result is reliable, whereas in the case of the purely hydraulic press and in the steam hammer, additional losses may occur which cannot very well be considered on account of their uncertainty. The excellent economy of the direct-acting steam-hydraulic press presupposes that no dead volume of clearance space has to be filled before the motion of the steam piston against its full resistance begins. The importance of this last sentence is so great that the authors take the liberty of repeating it in different words. The expression used actually includes three separate facts: The steam piston of the intensifier must be in its starting position with practically no clearance; the movable anvil must practically rest on the piece to be forged; there must be no voids in the plunger and intensifier cylinder.

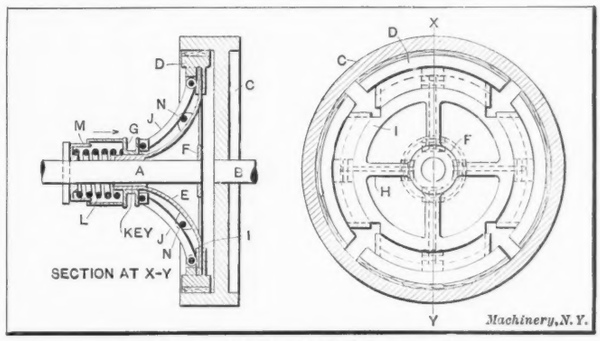
These three principles are embodied in the design shown in Fig. 4, which, in the authors' opinion, represents the most practical form which this type of press can assume. In this system the formation of voids in the water space is impossible, because the intensifier plunger floats upon the water at all times; in other words, the direction of motion of the intensifier piston and plunger is the same, which thus provides a continual force closure. If such force closure were absent, and in some types of steam-hydraulic presses it actually is, there would be no guarantee of a filled water space, and an increase of the steam consumption would be the inevitable result. Moreover it will be seen from Fig. 4 that the pressure is generated directly in the same cylinder in which it is used, thus avoiding the losses which must occur where the intensifier is separated from the press itself and the pressure water has to be forced through pipes and connections.

In Fig. 5 is shown an 800-ton four-column steam-hydraulic forging press of the type described, built by the Mesta Machine Co., of Pittsburg, Pa., and installed in the company's works at West Homestead, Pa. In Fig. 6 is shown a 200-ton single-column press built by the same company.

* * *

NEW-TYPE FRICTION CLUTCH

A friction clutch embodying some new features is the subject of patent No. 994,379, which has been granted to George E. Faile, New York City. This clutch consists essentially of an outer cylindrical rim, against the inner surface of which are applied four leather-faced shoes, these shoes being operated by links connected to a sliding collar located on the shaft *A*. The accompanying illustration shows sectional views of this clutch, *A* being the driven shaft and *B* the driver; *C* is the pulley or flywheel, against the inner rim of which four leather-faced shoes *D* bear. The inner face of the flywheel *C* is shown straight, but may be slightly cone-shaped if desired. Keyed to the shaft *A* is a hollow substantial conical member *E* presenting an outer annular flange lying in a plane at right angles to the axis of rotation of the shaft. On the left end of this conical member is mounted a cylindrical collar *G* which, as shown, is keyed to the shaft. The hub *F* has four arms *H* projecting from it, which add to the rigidity of member *E*. The flange *I* is provided with four



A Friction Clutch with Modified Toggle Action

V-shaped notches having an included angle of about 90 degrees. The four shoes *D* are mounted upon this flange, being grooved to fit over the flange. The annular part of each shoe has a lug formed integral with it, in which links or arms *J* fit.

The sliding collar *G* is grooved, and can be operated by a yoke, not shown. This collar is acted upon by a spiral spring *L*, supported in a collar *M* which bears against a pin driven through the shaft. The collar *G* is provided with four lugs in which the links *J* are held by pins. It will be noted that as the collar *G* is moved to bring the shoes into operation, the links *J* travel over rollers *N* and, as the shoes reach their operative position, they are thus firmly braced. The rollers resist any tendency of the links to bend, and at the same time prevent any strain being brought against the flange of the conical member. The flanges on the shoes are so connected to the links that the latter resist any tendency of the shoes to be thrown outward by centrifugal force when the clutch is not engaged. The shoes are so formed as to engage with the sides of the notches in the flange *I* or, in other words, fit over the flange, so that they are prevented from any circumferential movement in respect to the flange.

* * *

According to experiments recorded by *The Brass World*, the proportion of boracic acid that can be used in a nickel-plating solution without having it separate, is as follows: Nickel-plating solution, 1 gallon; boracic acid, 6 ounces. These results indicate that much more boracic acid can be used in a nickel-plating solution than is usually supposed.

OXY-ACETYLENE WELDING AND THE EDISON STORAGE BATTERY CAN

By J. F. SPRINGER*

The Edison storage battery is contained in a steel can hermetically sealed at its seams; it is made from steel plating 0.015 and 0.025 inch thick which has been previously nickel-plated. The can is square or rectangular in cross-section, the corners being slightly rounded. The vertical wall is made from a single sheet bent at the four corners. The weld is of neither the lap nor butt form, but instead the edges of the plate are bent outwards at right angles to the wall of the can thereby forming a slight ridge, consisting of two thicknesses of metal which are welded together. The seams where top and bottom join the wall are formed in the same way; thus, the bottom is a stamping in which the edge is turned up at right angles to the main surface, and fitted into the vertical wall with the depression to the outside. The top is similarly arranged. The turned-up edge has no joint at the corners and is about 3/16 or 1/4 inch deep. The object of this article is to describe the welding operations.

The Side Seam

To weld this can, the operator has one straight-away seam and two duplicate rectangles or squares with rounded corners. At the works of the Edison Storage Battery Co., Orange, N. J., from the screw for the return or for any other movement. The work is held by two clamps which are shown in the two illustrations, Figs. 1 and 2. One of these is hinged to move in a vertical plane; the other, in a horizontal plane. The ridge of the seam lies between them when they are in position. The work is put on the holder, with the seam uppermost, horizontal and to the rear; it lies perhaps half an inch from the adjoining wall of the can. The vertically moving clamp is secured in position on the front side of the ridge. Also, the horizontally moving clamp is locked; this clamp has a dihedral face. The horizontal portion fits into the narrow space along the rear of the ridge; the vertical face presses against the rear face of the work.

The surface of the holder immediately below the seam is grooved out perhaps an eighth of an inch deep. The surfaces of the clamps are beveled off so as to form a valley with the seam between the bevels. The bevels are very steep—about 60 degrees—and hug the ridge pretty closely. The torch is inclined at an angle of about 45 degrees. When the torch is lit, and the small inner flame—the working flame—is formed, the tip of this flame and the seam are in contact or quite close together. The hollow beneath the seam acts as a heat insulator to confine the effects of the flame to the work. The 60-degree groove combined with the position and character of the flames operates to split the outer—the enveloping—flame, with the result that it fills the groove front

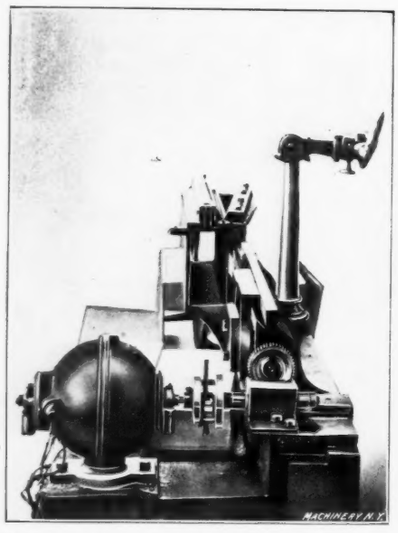


Fig. 1. Machine for Welding Longitudinal Seam, ready to receive Work

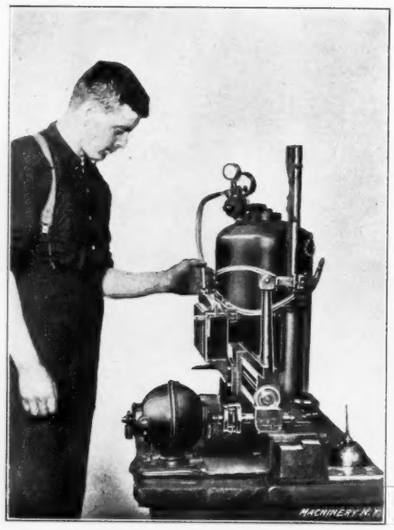


Fig. 2. Closing the Holding Device preparatory to Welding the Longitudinal Seam

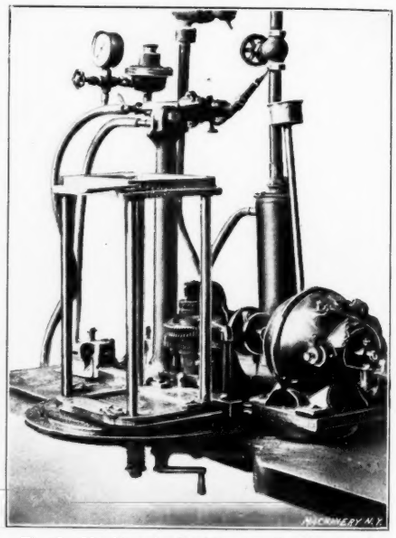


Fig. 3. Machine for Welding on the Tops and Bottoms of the Storage Battery Cans

both styles of seams are acetylene-welded by automatic machinery. The apparatus used with the straight-away seam is, as one would naturally suppose, the simpler of the two, but in both, however, the torch is absolutely fixed and the work is carried past. There is a vertical post, at the upper end of which a movable arm is arranged, and to this arm the torch is secured, being horizontally located while welding. Between times, it may be thrown back out of the way, along with the torch. In the case of the straight-away machine, the post is placed to the rear and at the left end of the carrying device as indicated in Figs. 1 and 2. A small individual motor supplies the power, this motor being arranged in front and to the right of the operator, its horizontal spindle projecting toward the rear. Another horizontal spindle carrying a worm is driven by the motor spindle, connection being made in the following manner: Each spindle has a circular plate with two projecting pins, which overlap a large part or nearly the whole of their length as indicated in the illustrations. A leather strap run around the pins secures the whole together, the leather thong introducing a somewhat elastic connection. The rapidly turning worm rotates a worm gear, but as even the speed of the latter is far too great for a welding movement, it, in turn, rotates a screw, thereby giving the carriage a slow rectilineal motion, which, ordinarily, is perhaps a foot a minute. The carriage can be released

* Address: 608 W. 140th St., New York City.

and back of the inner flame. That is to say, the unwelded seam ahead is covered for several inches; and also the welded seam to the rear. The atmosphere is thus very effectively excluded from the vicinity of high temperature on the work. This arrangement gives an effective means of preventing oxidation of the work. At the Edison works, the seam can be welded with no discoloration except at the beginning and end. It would appear that even these discolorations could be avoided by bringing the torch into action with the outer flame fully split and doing this well in advance of beginning the weld; and by continuing the flame conditions beyond the work. The edge where the weld is located is, except at the ends, just about the color of the nickel-plated sheet. However, what is seen is probably steel—for the most part at least.

Considerations for Avoiding Oxidation

The matter of avoidance of oxidation is so important that it will be profitable to consider the matter more fully. The oxidation of steel may take place at a low temperature, the familiar form of this type of oxidation being rust. Apparently, two things are necessary—moisture and free oxygen. As water usually contains free oxygen in the form of atmospheric air and the atmosphere ordinarily contains water vapor, these conditions are often realized. The consequent oxidation is, however, not that which the welder has to fear; it is quite easy to get rid of the water. However, oxides of

iron—higher oxides—form at high temperatures, and apparently, the presence of moisture is not necessary to produce these, for, given the temperature and the oxygen, the oxide will be formed. The acetylene welder certainly gets high temperatures; the oxygen may come from two sources. The very flame with which he works is formed by the combustion of acetylene (C_2H_2) by oxygen, the oxygen coming from the gas jet which feeds the flame. What takes place immediately the mixture of acetylene and oxygen leaves the nozzle appears to be substantially this: The acetylene is dissociated into its constituent gases—carbon and hydrogen; the carbon burns to carbon monoxide, using up in this way exactly as much oxygen as acetylene. The hydrogen and the carbon monoxide are both eager for oxygen, but the temperature of the little inner flame is probably everywhere too high to permit the formation of water vapor or of carbon dioxide. If this is a correct statement of the facts, then any excess of oxygen coming from the nozzle will find its way into the region exterior to the small flame.

Now the oxy-acetylene torches do supply an excess of oxygen; it is necessary, in fact, to supply an excess—a result obtained from experience. The Davis-Bournonville torch requires an amount of oxygen which is perhaps as small as or smaller than that required by any other torch now on the American market. This torch requires the exact amount of 1.28 volumes of oxygen to 1 volume of acetylene—both gases at ordinary pressure. This excess of 28 per cent is required probably because of some residual imperfection in mixture. Now what becomes of the excess? Does it operate in the direction of oxidizing the work? Experience would seem to say, No—at least for a torch with only a 28 per cent excess. And we can understand how this may be. While the temperature of the tip of the little flame is exceedingly high—claimed to be 6000 degrees Fahrenheit—that of the work is much less. With sufficient reduction of temperature, there are two other bidders for the oxygen—the hydrogen and the carbon monoxide. It would seem probable, then, that, with the moderate excess of 28 per cent, these gases are competent to deal with it to the exclusion of any absorption of oxygen by the work. It would appear reasonable that gases such as carbon monoxide and hydrogen would more easily effect combination with oxygen than a metallic substance. We can, however, not expect them capable of dealing with any considerable percentage to the exclusion of the metal. This question of the exact behavior of excess oxygen might profitably be taken up by some one of our technical schools and brought to a final determination. In practical work, it is doubtful whether much trouble from this cause will be experienced by the careful operator. Oxidation will probably result, if the excess is allowed to exceed to any extent the 28 per cent. The Davis-Bournonville torch is so constructed that the oxygen is very accurately proportioned to the acetylene when the small flame has its proper form; this can be determined by an operator with ease after a very little experience. This flame affords, in fact, a very sensitive guide.

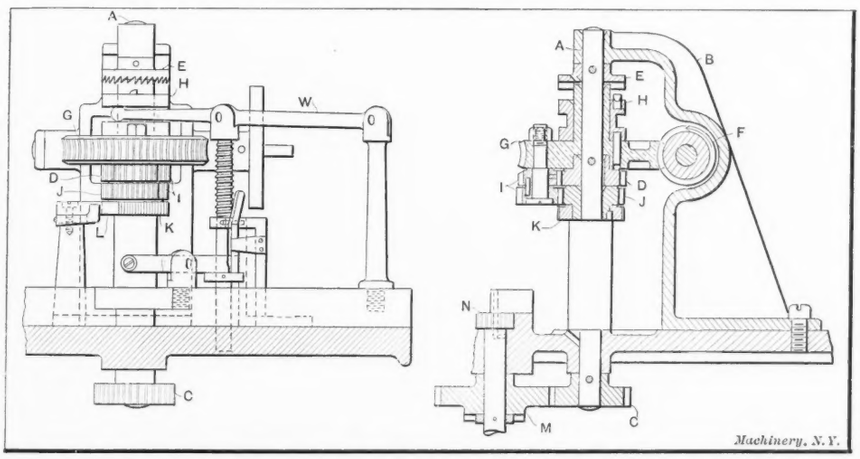


Fig. 4 Feed Arrangement for automatically moving the Can End under the Oxy-acetylene Welding Torch

There is another source from which oxygen may find the heated metal—the surrounding atmosphere. The oxygen here is very much diluted, but the supply is inexhaustible—limited, in fact, only by whatever difficulties of access may be present. The problem, then, is to provide adequate safeguards. When the torch is lit but not in use, the working point of the small flame is everywhere surrounded by protective gases, thus being effectively shut off from the atmosphere. A solution is thus presented, if it is possible to maintain an envelope of protective gases. When we bring the tip of the small flame into contact, or approximate contact, with the work, we are apt to break up the envelope at some point and admit the atmosphere. However, we can, no doubt, frequently so dispose the torch with reference to the work that complete protection is insured. This is exactly what seems to be the case with the arrangements in connection with the straight-away machine at the Edison works. One can readily understand, however, that, if the human hand be depended upon, the risk of breaking up the exact relation would often be incurred. Except at the beginning and end of the seam, the controlling factors are absolutely fixed. These factors may be assumed to be: (1) the character and strength of the small flame; (2) its distance from the work; (3) its angle of inclination; (4) the form and size of the seam and adjacent metal; and (5) the form and size of the working groove. When these factors have once been correctly provided for by the machine, they are then easily maintained. If hand control alone is attempted, difficulty with Nos. (2) and (3) may be expected.

The portion of the outer flame which is beneath the small flame would seem to be effective in preventing oxidation. That is to say, the danger of oxidation from the atmosphere is not confined to that part of the work upon which the small flame is operating. When it has been passed, the new weld may still have a very high temperature, high enough, in fact, to bring about atmospheric oxidation. Now the outer flame which surrounds the inner one and extends beyond it for perhaps ten times its length (when the torch is burning free) is also hot, although not nearly so hot as the inner one. It is in this outer flame that we assume that the excess oxygen from the air is united with the hydrogen and carbon monoxide to form water vapor and carbon dioxide. It is consequently the scene of much combustion and therefore heat. In fact, the amount of this heat is considerably more than that evolved by the inner flame. The temperature is comparatively low because of distribution over a much larger space. The streamer from this outer flame which lies in the working groove and covers the new weld operates to shield the highly heated metal until its temperature sinks below the oxidation point.

In this straight-away machine, there is an angle of 45 degrees on one side of the torch and an angle of 135 degrees on the other side. The new weld is on the side of the smaller angle. There is a streamer from the outer flame which covers this new weld, as already explained, for a distance. The other streamer is on the other side of the smaller angle where the unwelded seam lies. It is a little difficult to see whether it operates in any very decided manner to prevent oxidation. It is quite clear, however, that it acts as a preheating agent. This is important from the point of view of speed and economy. The desired temperature for the welding operation is partly secured by the time that the inner flame begins to play upon a given point. The time required to secure the temperature is consequently reduced. The expense for labor and gases is thus reduced as well. Further, the output of the machine is increased.

In the work on the straight seam of the storage battery cans, it is possible, as will now be seen, to pre-heat and pre-

serve from oxidation by suitably directing and managing the outer flame. Where this is possible, it is the method which should ordinarily be adopted; it costs nothing extra. However, there may be work of such character that other means will have to be employed, either in substitution or as a supplementary procedure. There is no especial necessity, it would appear, why the auxiliary flame should consist of hydrogen and carbon monoxide; it would seem possible to use ordinary illuminating gas, natural gas, producer gas or some other convenient gaseous fuel. Separate jets disposed precisely as desired and supplying flames of the size and intensity necessary are thus possible. In other words, it is not necessary to be confined to the use of the outer flame of the oxy-acetylene torch. Thus, if the work is of such shape that it is impossible to so manage the outer flame as to provide a complete protection against oxidation, another heating jet can be used and directed in any way that may be necessary.

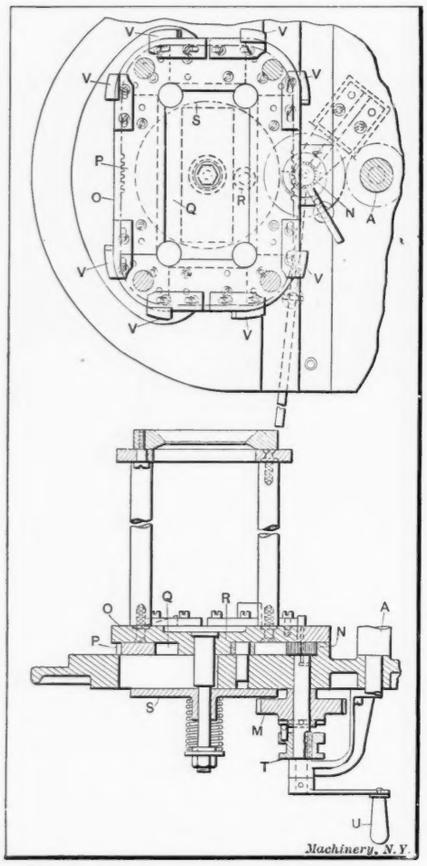


Fig. 5. Main Part of Machine for Holding Cans while the Ends are being welded

At the Edison works, a seam of perhaps 15 inches can be welded in about 1¾ minute. The material is quite thin, as previously stated; for such thicknesses, the machine method is the method to use, undoubtedly. To perform the work by hand requires too great steadiness, and an even, steady movement is exactly what a machine is adapted to give. In machine welding, it is quite usual to use no welding stick, the material for the weld coming from the work.

Welding Tops and Bottoms

The welding on of tops and bottoms constitutes a more difficult mechanical operation, the especial difficulty arising from the sharp curvature of the corners. The can is removably secured to a frame or jig and is controlled by a rack attached to it, the whole arrangement being shown in the halftone Fig. 3 and the details in the line engravings Figs. 4 and 5. The controlling rack has a pitch line of the same form as the outline of the plan of the can, and is driven by a suitable pinion. Because of the sharp curvature of the corners of the can, and the necessity of using a reasonably large pinion and depth of tooth, the pitch line of the rack lies considerably outside the can outline. Now the speed of the can will be the same as that of the rack on the straight-away portion; but, at the corners, the linear speed will be less. In order, therefore, to secure a uniform speed of movement of the seam beneath the torch throughout the whole operation, the speed of the rack at the corners is considerably increased. Other conditions being the same, if the linear speed were much reduced at the corners, these portions would be unduly heated by the slow movement.

The Edison Storage Battery Co. has overcome this difficulty by a mechanical device, which is very interesting although perhaps not original with them in its essential points. In its description, it may be as well to begin with the driving mechanism, which is shown in detail by the two views in Fig. 4. There is a spindle *A* mounted vertically in a frame *B*. The central portion of this spindle, it will be noticed, has a larger diameter than the remainder. Two gear wheels, *C* and *D*, are secured to the spindle, as is also a single-faced clutch *E*. There is a worm-gear arrangement, *FG*, through which power is transmitted. The hub of the worm-gear *G* is extended upwards to form a sleeve, the whole being loosely mounted on the spindle. The collar *H* may be moved vertically on the sleeve, but both are arranged to rotate together by the pin connection. On its upper face, this sliding coller is provided with one or more teeth to engage the clutch when the former is lifted a short distance. It will now be seen that with the clutch thus engaged, the spindle, and consequently the gear *C*, will be driven at the same angular speed as the worm gear *G*. This is the direct drive, and yields the quick movement desired when rounding the corners of the seam. Upon a pin through the worm-gear *G* is mounted a pair of small pinions *I*, near the periphery of *G*. These two little pinions are secured together, so that they rotate in unison, the stud providing a dead journal for them. A gear *J* is loosely mounted on the spindle. Upon a downward projecting hub of this gear, a toothed wheel *K* is keyed, the two rotating on the spindle as a single unit. The pinions *I* are always in mesh with the gears *D* and *J*. Swinging from a post, a ratchet finger *L* engages the toothed wheel *K*, permitting rotation in but one direction. Consideration will show that when the clutch *E* and the collar *H* are engaged no disturbing influence is exerted by the pinions *I* and the wheels *D*, *J* and *K*. In the first place, the parts *A*, *D*, *E*, *G* and *H*, all have the same angular speed, so that as far as the small pinions are concerned, it is only necessary that they remain immovable relatively to the gear *G*, on which they are mounted. This requirement will impose upon the pair *JK* simply a rotation in unison with the spindle; the ratchet arrangement permits this in the one direction. But, suppose now that the collar *H* and the clutch *E* are disengaged. Because of friction, the spindle will tend to remain still; that is to say, the gear *D* will provide a surface upon which the upper one of the small pinions will roll. The other small pinion will likewise turn because secured to its companion. From the difference in diameter of the gears in this four-gear train, the wheel *J* will be turned more rapidly than the wheel *D*. The effort will be in a reverse direction, but as *J* cannot be moved in the reverse direction because of the ratchet, the result will be that *D* will be driven in a forward direction. This will turn the spindle itself forward, because *A* and *D* are secured together. This forward movement, effected through reaction, is much slower than that resulting from the direct drive. It is employed in connection with the straight-away portions of the seam. The motion, whether slow or fast, is communicated through the gear *C* to the gear *M*, and thence to the pinion *N*. This last drives the rack which is attached to the cage holding the work.

Fig. 5 gives two views of the main part of the machine in plan and elevation. The fragment of spindle *A* seen on the extreme right in the elevation is the spindle *A* of Fig. 4. The gear at its lower end is not shown, but the gear *M* of Fig. 4 is to be seen, here marked *M* also. The final driving pinion *N* is just above. There is a table *O*, to the under side of which a rack *P* is secured. Within this rack contour, shown by the plan, are two rectangles in dotted lines, forming the channel *Q*, in which the roller *R* operates, being located in this channel opposite the driving pinion. The table is kept in a true horizontal position by the assistance of the sliding plate *S*, which is held not too rigidly in position by a pin or bolt and spring. There are four upright posts secured to the upper side of the table. The can to be welded is placed within these and held rigidly in position by a clamp arranged at the top, which clamps the can diagonally, the manner being best illustrated in the halftone, Fig. 3. A suitable form is used within. The movable portion of the clamp consists of two arms at right angles, both form-

ing a single piece. By moving this angle along the diagonal passing through its vertex, closure and release are made. Pins and slots maintain the movement along the diagonal. The lever with a cam slot at one end enables the operator to produce the movement and to give force to the closure. The form on the inside consists essentially of four parts—all four forming a kind of pyramid cut by diagonal vertical planes. This device is put within the top or bottom to be welded, and readily expanded by a simple movement. This, with the exterior clamp, gives a very effective means for holding the metal edges of the work in exact position. Reference to the plan of Fig. 5 shows the driving pinion in mesh with the rack. Apparently, there is no need to drive at more than one point, the arrangements there affording sufficient control. Referring to the elevation in the same illustration, it will

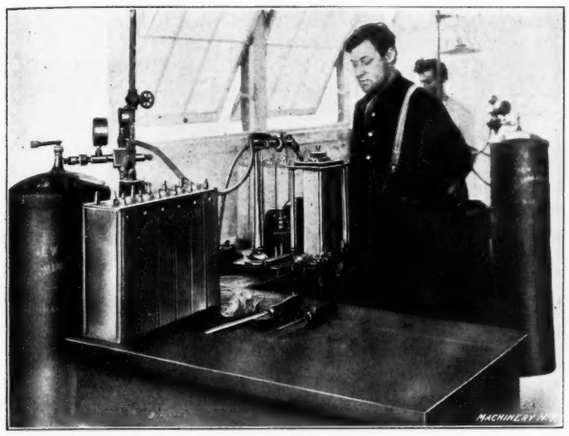


Fig. 6. Machine for Welding Can Ends in Operation. Finished Cans to the Left

be seen that in fact the rack is run through a kind of pass between the pinion and the roller, both being fixed in position. If, at any time, it becomes necessary to operate, say for a short distance, by hand, it is possible to do so, for by raising the sliding collar *T*, engagement is secured with a clutch face arranged on the under side of the loose gear *M*. The handle *U* may then be used to obtain the movement desired.

Fig. 5 also shows at the corners, the adjustable pieces *V* which serve to bring about the speed changes by moving the yoke *W* (Fig. 4) which is pivoted as a lever to the post on the right. By this means, the sliding collar *H* and the clutch *E* are thrown in and out of engagement.

The machine in operation, welding the ends of the cans, is shown in Fig. 6.

* * *

The city of Milwaukee appears to be the first city in the United States to apply the methods of scientific management in the running of the city's affairs. A Bureau of Economy and Efficiency has been established, which in its first semi-annual report, just published, shows that as a result of the investigations made by the bureau nearly $100,000 can be saved the city by the application of economical and efficient methods. Among other things the bureau has started a study of purchasing methods, including standards, specifications, inspection and testing of purchases, and has made a study of the best purchasing methods employed by large private corporations, for such suggestions as may be found useful. Municipal engineers everywhere will undoubtedly be interested in this work, and in the reports that will be forthcoming, because the standards according to which the business of most of our cities is run are usually contrary to all accepted methods of private enterprises, and the engineer who, as an employe of the city, has been called upon to perform work under the inefficient methods usually in vogue, must have felt the need of some comprehensive research work in this direction. Advanced thinkers will not think it strange that Milwaukee takes the lead in this respect, it being the only city of importance in the United States to have a socialistic municipal government.

A MODERN GERMAN METAL-WORKING PLANT

ARRANGEMENT, MANAGEMENT AND OPERATION—COOPERATION WITH AMERICAN TOOL BUILDERS

By C. A. TUPPER*

In writing of European shops, and comparing their practice with that of American plants, it is difficult, because of the vastness of the subject, to avoid mere generalities, and most of the articles published suffer from that defect. On the other hand, if one goes very much into detail, more space is soon covered than the average editor is willing to allow, and the treatise ends with an abruptness which leaves the impression that it is very fragmentary. In the following, therefore, the writer will refer principally to only one of the plants of Europe which now typify the best practice on the Continent, and, by bringing out the features with which he was most impressed, give an idea of what he saw that has suggestive value for manufacturers in this country.

Almost every American who makes a round of German metal-working plants visits the new foundry, machine and assembling shops, show-rooms, etc., which constitute the fine modern works of the Ludwig Loewe & Co. Akt. Ges., at Berlin. These are among the best equipped and most efficiently managed in the Empire, and there are many features of the entire establishment deserving of careful study. In its general layout the plant is stated to have been modeled partially on the lines of the Brown & Sharpe Mfg. Co., Providence, R. I., and there are certainly numerous points of resemblance. Nearly as many men are employed as in the American establishment, operating methods are very much the same, and in the products of the company, German skill and enterprise are seen at their best. One is impressed, on entering, with the excellent provisions for light and ventilation, the facilities for handling material, appliances for saving time and lightening labor, etc., and the intelligent appearance of the workmen, most of whom are in the prime of life. They move about at their tasks with a poise and decision and operate the machines entrusted to them with a quickness and certainty that astound many Americans who, coming straight to Berlin from the United States or from London, *via* Hamburg, visit a German shop of this class for the first time.

In its work the Loewe company combines American and English methods with others that are peculiarly its own, the management having apparently the faculty of picking out the best of various diverse characteristics. Relations with England are very close, and one would say that many ideas have been taken from both the old and new plants of Alfred Herbert, Ltd., Coventry, whose work has undoubtedly made more of an impress on the Continent than that of any other British firm.

Like Herbert, the policy of the Loewe company seems to be to manufacture for stock as much as possible, and the tendency during recent years is towards increased specialization. While a greater variety of tools is still built than many American firms would care to undertake, in accordance with general German practice, the Loewe company is only pushing a limited line, including automatic lathes, automatic screw- and gear-cutting machines, milling machines, drill presses, grinders, etc., as well as high-speed tools of standard design for the same general classes of work.

Handling American Agencies

This concern has, however, put itself in a position to keep on hand a very complete stock of machines of all kinds by acting as agent for many of the most advanced American tool-builders, including the Colburn Machine Tool Co., Franklin, Pa., for boring mills; Fosdick Machine Tool Co., Cincinnati, O., for plain and universal radial drills, horizontal boring, milling and drilling machines, etc.; Cincinnati Planer Co., Cincinnati, O., for variable-speed planers; Norton Grinding Co., Worcester, Mass., for bench and floor grinding machines, car wheel grinders, crank and crankshaft grinders, universal tool and cutter grinders, and a line of special apparatus of

* Address: 389 Thirty-first Ave., Milwaukee, Wis.

this kind for locomotive and car shops; Becker-Brainard Milling Machine Co., Hyde Park, Mass., for plain and universal millers; F. E. Wells & Son Co., Greenfield, Mass., for universal grinders; Ransom Mfg. Co., Oshkosh, Wis., for grinding machines; Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass., for lathes and planers; Springfield Machine Tool Co., Springfield, O., for high-power rapid-reduction lathes; and the J. T. Slocomb Co., Providence, R. I., and others, for a complete line of the best tools and machinists' supplies. There are probably additional firms represented, but the above are the only ones of which the writer made a memorandum, and they are sufficient to show the wide range of apparatus handled. With the large list of American firms whose interests are in the hands of De Fries & Cie, of Düsseldorf, Germany, it is also remarkable as demonstrating the confidence felt by manufacturers on this side in the fairness of these leading German concerns, who are, in part, direct competitors. Much of the Loewe company's construction is distinctively German and stands for the new, independent order of designing that has become current in the Empire within the last few years. The company also manufactures some special machines, peculiar to German shop methods, which have no practical interest for Americans.

While the workmen employed in various parts of the plant are quick and handy, the average is probably not quite up to the American standard, as, even with the considerable use of automatic tools, it takes a larger force for operating them than would be required in one of our modern plants. More skilled, *i. e.* machinist, labor is also needed.

The works contain many American and some English tools, and the writer was informed, although he did not see for himself and is inclined to doubt the assertion, that they had obtained service from these tools which was not intended by the manufacturers. In fact, applications of standard American machine tools to special work, at various other places in Germany, upon which the Teutons naturally laid stress as examples of native ingenuity, turned out to be the same as those made in many American shops. Special attachments and devices, such as for indexing, could also be paralleled at numerous places in the United States.

The care taken with all work, from the foundry to the shipping department, is, however, worth any American's time to observe, and it undoubtedly results, at the Loewe plant, in a very high grade of product. Everywhere there is neatness, order and system; passages, even in the foundry, are kept unobstructed; there is no misplacing or cluttering of material, and the risk of accident has been reduced to an absolute minimum.

In the sales department, machines are demonstrated to customers by being put at the work for which they are intended; and all apparatus, before being packed for shipment, is tested in the finishing department. Under these circumstances there are few "comebacks," and the system is one of as much advantage to the American manufacturers whom the Loewe company represents, as to that concern itself.

Developing an Efficient Working Force

It is, however, in the systematic development of trained, loyal workmen that the Loewe company has evolved the methods which are most worthy of emulation by Americans. The apprentices, a large number of whom are annually taken into the works, not only learn their trade but are given instruction in a good school, which is recognized by the local authorities as a regular continuation school. There is very thorough teaching of mathematics, including not only arithmetic but trigonometry, algebra and geometry; and any lad who displays an aptitude for drawing is given particular encouragement in that line.

When it comes time for serving in the army, the young graduates from the apprenticeship course take their turn with other German youths; and the most of them go forth as journeymen machinists, with the recommendation and cooperation of the company. Others return directly to its service. When the wanderers come back to Berlin, as a fair percentage eventually do, places are found for them at the Loewe works as soon as possible, and the utmost benefit is derived from the experience which they have had elsewhere. Soon after each man's return, there is very apt to be a communication from him in one of the suggestion boxes. For good ideas, payments or other suitable rewards are made; and, from the first period of their apprenticeship, the men are encouraged to think for themselves. In this respect it seemed to the writer that the Loewe works are ahead of most other German plants, although initiative has, undoubtedly been stimulated all through the Empire, if one is to compare present conditions with what investigators reported even ten years or less ago.

While the men who have graduated from the Loewe shops are serving as journeymen machinists in various other industrial centers, they help to introduce the products of the company by talking about them. This is more or less involuntary, from the fact that the men learn, even as apprentices, to take great pride in the work that is being turned out, and, when they get out among others of their craft, they naturally brag about it. This remains true, also, of the men who marry and settle down permanently elsewhere. Many of them continue to "plug" for the old company.

By the time those who return to Berlin are back in the Loewe shops again, they have become matured and well balanced, which is probably what impresses upon the visitor the fact that so many of the machinists are in their prime. This, of course, constitutes a very desirable class of labor and no doubt contributes largely to the general efficiency of the works.

Future Competition for European Trade

The Loewe tools bring good prices, which is one thing that enables them to be handled with American machines to advantage. They have been placed all through Europe, even overcoming racial prejudices, as in France, Bohemia and Poland. A large percentage of trade is with England. For export to other countries over-seas there is also a growing volume of orders, special attention being paid to this business as a steadying influence on the European market and a desirable asset for the future.

From the side-lights cast by the above on the activities of a first-class German machine-tool plant, it will be seen by anyone not already informed, that Americans no longer have a "walkaway" when it comes to the best work in that line.

The writer cannot, however, agree with the people on this side of the Atlantic who see in the rise of German manufacturing the doom of the American machine tool trade in Europe. The enormous industrial expansion that has taken place there, of late, and is still in progress, brings with it a demand for new equipment which it will tax European tool builders to supply, particularly as they have entered upon a fixed policy of maintaining their export trade over-seas, no matter what the market at home may be. There will be room, for at least many years to come, for the sale of the best American and European tools side by side; and the independent designing entered upon by such firms as Ludwig Loewe & Co. Akt. Ges. will benefit all manufacturers in this line, without regard to country, for the reason that it tends to raise the general standard of mechanical efficiency demanded by users. The increasing use of high-speed, modern tools, and the application of improved shop systems in one plant forces similar betterments in those that compete with it, and the circle of demand is thus rapidly extended. Such concerns as the Loewe, Herbert and Brown & Sharpe Cos., or others equally representative of their respective countries can, therefore, well afford to cooperate in every possible way, instead of retarding each other's progress, for the general promotion of trade which results is of direct benefit to all.

* * *

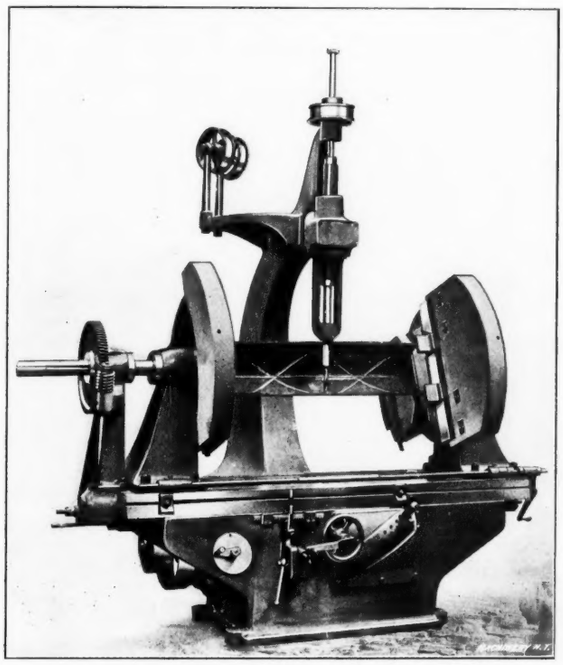
One of our British contemporaries mentions that an electrical concern in London, wanting to send an urgent consignment of metallic filament lamps to a town some distance from London, adopted the method of sending them through the air by a monoplane. The journey was successful, but there is a doubt in our mind whether the company considered the consignment very urgent when it adopted the monoplane method. It would seem that this would have been the very worst way to send it, had it been very important.

OIL-GROOVING MACHINE

By W. H. HAGGAS*

In the May number of MACHINERY, the writer noticed a paragraph in which a regret was expressed that there are no oil-grooving machines made in America; for that reason the writer wishes to bring the attention of the readers of MACHINERY to such a machine made by Ward, Haggas & Smith, Keighley, England. This particular machine is designed not only to mill oil grooves in half-bushings, but also to chamfer the edges. In capacity, it is designed to handle half-bushings, ranging in size from 48 inches long by 24 inches inside diameter to 6 inches long by 4 inches diameter, and is adapted for milling these grooves either straight or spiral. In the latter case half-spirals can be made in a range of from 4 to 24 inches in length. Needless to say, the machine produces a much neater job than is possible by hand, and, on the average, can make the grooves about six times as fast, having the additional advantage of making it possible to save the brass cuttings.

The construction of the machine is very simple. The bed is of an inverted T-shape in plan and carries a stiff section table with square guiding surfaces and long taper gibs. On this table are mounted two bearings which carry the chuck



Oil-grooving Machine for Cutting Oil Grooves in Bushings

or faceplate which is designed to hold the bushing to be milled concentric with the bearings. The bearings may be adjusted along the length of the bed by means of a right- and left-hand screw in order that bushings of various lengths may be accommodated. As will be seen from the illustration, the left-hand chuck plate carries a splined shaft which slides through the boss of a large worm-wheel. This worm-wheel is geared to the table traverse so that the two move in unison.

By means of the plunger handle in a notched plate in the front of the machine, the relative movement of the worm-wheel and table may be changed so as to give from a half circle in a 4-inch travel of table to a half circle in a 24-inch travel; ten changes are possible by this selective gear arrangement. The right-hand chuck plate has no means of power drive other than through the bushing being milled, but as both chucks are balanced, no strain is placed upon the bushing. The direction of rotation of the bushing can be changed at will by means of the handle on the dial plate so that instead of cutting right-hand across from corner to corner, a saw-tooth course may be followed. This is accomplished by letting the table travel along half its course and then reversing the revolving motion. The vertical handle and short rack seen at the front of the machine will reverse the direction of both the table travel and the bushing rotation. The dogs shown along the side of the table are set to limit the travel of the table. The ball handle at the front of the machine operates a drop worm which when out of gear permits the table or chuck plates to be adjusted by hand.

The upright carrying the milling spindle has a 9-inch crosswise adjustment on the back part of the bed and is operated by the handwheel at the front of the bed. This adjustment is introduced so that chamfers may be milled on the edge of the bushing. The cutters used are usually short twist drills, the spindles having a Morse taper to suit. The spindle is vertically adjustable by means of the handle in the center of the handwheel for adjusting the column.

The machine is driven by pulleys shown on the left of the machine, two sizes being provided to give the two required speeds, one for brass and the other for cast iron. This motion is carried through a short shaft in the bed on which are mounted pulleys for driving the spindles and feed gear. The feed gear, driven from this shaft by a belt, is transmitted through a friction reversing clutch and then by worm and worm-wheel in the bed under the table. This worm-wheel is mounted on a screw which moves the table.

Care has been taken in the design to have all the adjusting levers at the front of the machine within easy control of the operator. In addition, the machine is easily and quickly changed to accommodate either a large or small bushing, and the notch plate is calculated to suit various lengths.

* Address: 26 Ashleigh St., Keighley, York, England.

* * *

MACHINES VS. MANUAL LABOR

At a time when the use of machinery for performing nearly all operations in the manufacture of products of iron and steel has been so thoroughly established, and when its effect on the industries and on the general economic conditions of nations has been so fully recognized, it is rather surprising to find the following paragraph in one of our British contemporaries:

"At a conference of the Factory and Cable Chainmakers' Association, held at Cradley Heath on the 10th of July and attended by delegates from South Wales, Staffordshire, Worcestershire, Chester and Lancashire, it was stated, according to a report in the *Manchester Guardian*, that there was a great revival in the cable chain trade. Satisfaction was expressed that the wonderful machines imported into England to displace hand-made chain had proved absolute failures. Some, it is said, had been thrown onto the scrap heap, and a communication from America states that the big machines erected there had also proved failures. One was draped in mourning in memory of the vast amount of money spent on it."

The idea that the introduction of machines to perform operations which have formerly been carried out by manual labor is a development injurious to the best interests of the worker at a trade is one that seems to be imbued in the minds of a great many people. No doubt examples can be pointed out where the introduction of machines has thrown a number of men out of work temporarily, but, nevertheless, in the long run, not only has the community in general, but these men as well, been benefited by the introduction of the machines. No doubt, if it were not for agricultural machinery, thousands of men could be employed on the farms in the United States, for example, that are now displaced by highly developed modern agricultural implements, but does anybody believe that the average standard of living in the United States would be as high as it is, were all the farm labor performed in the manner of a hundred years ago? The development of new machines which make it possible to produce more quickly and cheaply will, in the long run, react satisfactorily on all, and if—due to social and economic mal-adjustment—the man who is displaced by a machine cannot without difficulty find some other occupation which will yield him as good a living, he should not blame the machine, which in the main has a beneficial influence, but the incongruous economic conditions which are permitted to remain unaltered.

* * *

The supply and condition of wrenches is often a guide to the characteristics of the man using—or abusing—them.

THE DISAPPOINTING AIR RECEIVER*

By FRANK RICHARDS†

In speaking here of air compressors, and more particularly of the air receivers which always accompany them, the writer has in mind those installed for service sufficiently permanent to warrant the provision of safe and economical working conditions. This includes air compressors which are installed in most of the plants of any considerable capacity. Compressed air is used as a necessity for operating rock drills, when sinking shafts, driving tunnels, and in general mining work, etc. It is also used as a time and money saver in still greater volume for a much wider range of service. Every extensive manufacturing plant must have its compressed air supply distributed throughout its works; for the larger engineering operations, such as dams and waterworks construction, and in the most extensive quarries, compressed air is superseding the isolated steam-operated pumps, hoists, shovels, stone crushers, concrete mixers, etc.

In all these extensive lines of air service, and, in fact, in all air practice, it makes a great difference as to the condition of the air when used, and especially as to the moisture which may be carried in it, much inconvenience and loss of time occurring when the air is not kept dry and clean. There is always a pretence made of attending to this necessity. Who would think for a moment of installing an air compressor without a good sized air receiver as close to it as possible? The man who would set up an air compressor without an air receiver would lose all his respectability among engineers. Respectability has, perhaps, a good deal more to do with the installation of an air receiver than anything else.

If you were to ask the whys and wherefores of an air receiver, you would probably be told that "everybody always uses them." If you pressed the matter still further, you would mostly likely be told that the receiver is needed for the storage of air and the steadying of the flow. Well, the total capacity of the air receiver usually installed with an air compressor does not exceed the output of the compressor for one minute. If the compressor is running continually, and if the air is being used as fast as it is delivered, the apparatus driven by the air must come to a standstill within a single minute. So it can be readily seen that the air receiver as a storage adjunct is of little value. Builders and sellers can afford to have you pooh-pooh the storage service of air receivers, but they will still assert the two-fold need of them for cooling the air and for getting rid of the moisture in it, the presence of the latter being the most serious objection to the air in use and the cause of the most trouble. Now as to the cooling of the air, how can the receiver do it? To cool the air as it comes from the compressor, there must be a cooling surface or material for the air to come in contact with, and to which it may impart its heat. The air receiver, however, is a plain cylindrical shell with no pretence of a cooling device or any arrangement of the sort within it, and the air merely passes through it hurriedly, emerging at the other end practically as hot as when it entered, giving up its heat more or less rapidly to the inner surface of the pipes through which it travels, for which cooling effect the pipes and not the receiver should have the credit.

It is a curious fact that the air receiver, so far from being an air cooler, has often been transformed into a combustion chamber. Numerous authenticated instances are cited of receivers which have become red-hot while compression and transmission were going on, and flames have been emitted at the ends of the pipe at a considerable distance from where the air was used; receivers have also sometimes exploded, which is much worse. When single-stage compressors are worked up to desirable service pressures, say 80 to 90 pounds gage, the temperature of the air discharged (water jackets having very little effect upon it) is high enough to volatilize the lubricating oil used; this oil-gas mingling with the air in such proportion as to form an explosive mixture, may be diffused through the receiver and into the pipe lines. Then if there is a sufficient increase of temperature to cause spontaneous ignition, or if there is a friction spark, disastrous and often fatal explosions result. It is well known that for the formation of an actively explosive mixture of oil-gas and air, the two constituents must be mingled in certain proportions, the limits of which, in either direction, have been quite precisely determined, and if either the oil-gas or the air be in excess when ignition occurs, there is no sudden explosion, but simply the active combustion which makes the receiver and air pipes hot. Although this is sufficiently alarming when discovered, it may be assumed that the danger of explosion is past.

If lubricating oil is used to excess in the air cylinder, it may accumulate in pockets or upon the horizontal surfaces for a considerable time, and when favorable conditions occur it may take fire and burn from the surface, just as the soot in a chimney takes fire. The activity of the combustion is not to be wondered at when it is remembered that on account of compression, the quantity of oxygen per unit of volume has increased six-fold or more, according to the pressure carried.

While the air receiver is not, thus, a cooler of the air, it also is not, for the same reason, an abstractor of the moisture in the air, this being the most desirable service which it could render, and which it has been too readily assumed to do. It is well enough understood that atmospheric air—free air—always carries moisture and also always has capacity, or as we might say appetite, for more, up to the point of saturation, when its avidity suddenly ceases. The moisture-carrying capacity of the air rises very rapidly with its rise in temperature, and diminishes, but not so rapidly, with rise of pressure. As the pressure must always be at the highest point just when the air is leaving the compressor, if we can then reduce its temperature to the lowest point, the air will be in a condition to surrender so much of its moisture that none will be found later to cause trouble, when lower pressures and perhaps higher temperatures are reached further along the line. It being thus sufficiently evident that the best place for drying the air is as near the compressor as possible, the first requisite is an efficient cooler or, rather, aftercooler for the air.

The air receiver, as has been said, has never been a cooler of the air, and the builders are now testifying to this fact by the number of aftercoolers they are offering. The best of these are highly efficient, and the air after going direct from the compressor and through the intercoolers is in the precise condition desired—that is, of high pressure and low temperature—for the surrender of its moisture. For the important service which the aftercooler may render, nothing could be expected to work more cheaply. There is only the first cost of the apparatus and connections, and then a sufficient supply—not large—of free running water.

Now, surely the air receiver is available for depositing the excess moisture which the aftercooler has liberated, and for sending forth the air sufficiently dry for all subsequent employment. Unfortunately, the typical air receiver still persists in its inefficiency, and the air passes through and out of it wet, or carrying a considerable amount of free moisture. It is to be remembered that when the saturation point is lowered by the lowering of the temperature of the air, and there is a relinquishing of the surplus moisture by condensation into water, that water still remains in the air, as mist or fog, and what is then needed is a separator. Any of the separators which are successful in drying steam are equally efficient in taking the liberated water out of the air, when it is in the condition here spoken of.

An air receiver of the common type, preferably horizontal, if merely provided with a series of baffle-plates (which might be added without much additional cost) would be an efficient separator, provided that the air passing through it is in the prescribed condition of high pressure and low temperature. Indeed it would seem to be quite possible to combine in one apparatus the two functions of cooling the air and separating the freed water from it, and it might also be made large enough to constitute a storage capacity equal to that of the plain air receiver.

* For additional information previously published in MACHINERY, see "Air Compressor Design," June, 1911, engineering edition, and other articles there referred to.

† Managing Editor, *Compressed Air Magazine*, New York.

NEW CAN-SEALING MACHINES OF THE MAX AMS MACHINE CO.*

By FREDERICK H. MOODY†

An interesting description of the manner of making solderless cans for food products was given by Mr. Ralph E. Flanders in the September, 1909, number of MACHINERY, the machines considered being those produced by the Max Ams Machine Co., Mt. Vernon, New York. With one exception the machines and processes are still substantially the same as

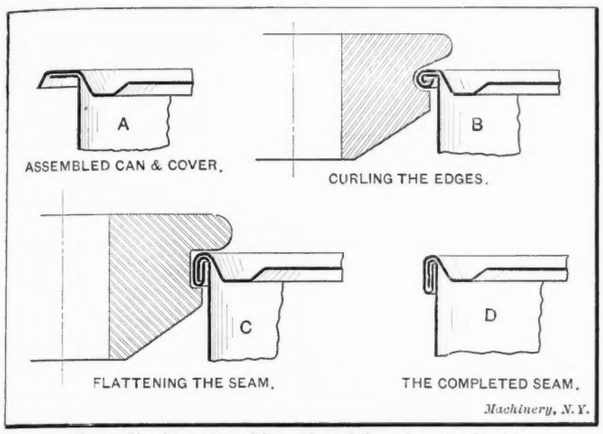


Fig. 1. The Sequence of Operations followed on the Double-seaming Machine

then described, and it will be unnecessary to cover the ground again, the interested reader being referred to the previous article for details not shown here.

The Seaming Principle

The particular change in the process lies in the newer application of rollers to double-seaming the covers, making the devices more compact. In order that the process may be

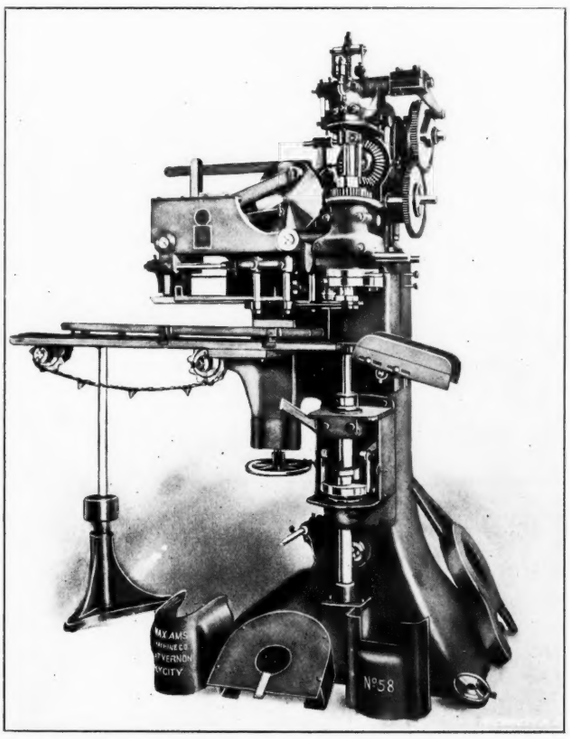


Fig. 2. Revolving-head Double-seaming Can Machine with Automatic Feed

more readily understood it is advisable to first consider the principle of seaming. Fig. 1 shows the successive steps. At *A* the flared can body and formed cover as they come from the preceding operations, are shown assembled. The first operation is that shown at *B*, where a round-grooved roller gradually runs up against the flared edges, the can spinning around in front of it. This operation curls the edges to the shape indicated. Subsequent to this action of the round-curling roller, a square-grooved roller as at *C* flattens out the curled edges, finally tightening them down to the form shown at *D*, making a complete double seam, tightly locked. As no solder is used in seaming, the assembled parts at *A* are first coated along the contact surfaces with a thin emulsion of an odorless compound of a sanitary nature which fills all crevices as the seam is formed, making a perfectly air-tight joint.

In the old type of double-seaming machine, these two round- and square-grooved rollers were held on sliding parts at the rear of the machine, and as the can, held vertically between the circular faceplates, spun around, the two rollers in succession came forward and performed their duties. To replace this form of machine, two new types have been developed, in which the two rollers are held in the upper chuck making the machine very compact and self-contained. These two machines are the No. 58 with a revolving roller head, and the No. 68 with a stationary roller head.

Revolving-head Double-seaming Machine

A revolving-head double-seaming machine is shown in the half-tone Fig. 2. The mechanical construction of the

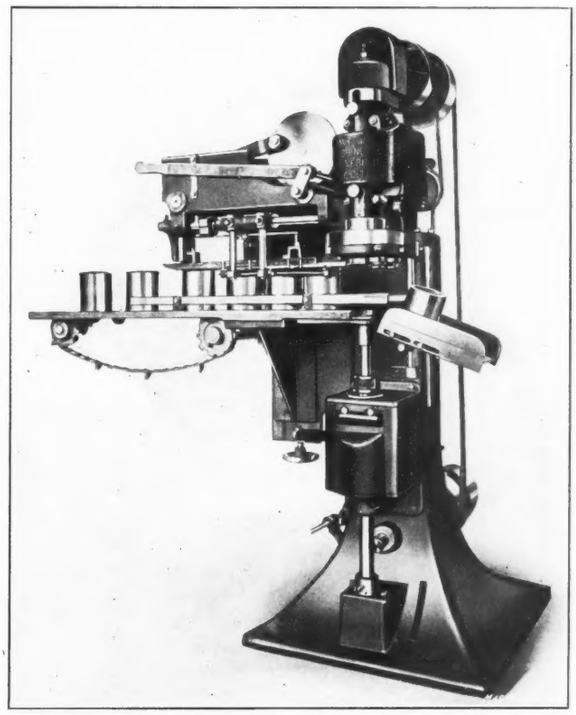


Fig. 3. Stationary-head Double-seaming Can Machine with Automatic Feed

head is very ingenious; the most important part of the mechanism is shown in Fig. 4. The two rollers one of which is shown) are attached to the seaming ring *A* by pins on which they are free to revolve. This ring *A* is bolted to head *B*, which, in turn, is connected to a sleeve *C* by a radially-sliding pin connection, the object of which will be explained later. On the upper end of this sleeve *C*, a gear *D*, is keyed. The seaming ring *A* is thus driven through the train of gears, *D*, *E*, *F* and *G* from the main drive shaft *H*, the can meanwhile standing stationary and centrally located with regard to the path of the rapidly revolving rollers fitting over plate *I* on the shaft *J*. Shaft *J* is operated by a forked lever and a cam so that chuck-plate *I* is lowered when no can is fed to the seaming rollers. When a can comes under the chuck-plate, both can and plate are raised to the right height for the rollers. This height is regulated by the adjustable collar *K*. When a can is seamed, the chuck-plate drops again, collar *K* resting on the shouldered pin to the left. An interior rod acts as a knockout, to free the finished can.

* For further information on the subject, see the following articles in MACHINERY: "Making Solderless Cans for Food Products," September, 1909; and "Modern Can Manufacturing," July, 1911 (engineering edition).

† Address: 70 Bond St, Toronto, Canada.

Thus far, a very neat provision has been made for having the head revolve around the stationary can, but some means must be provided for having the rollers come up to, and recede from, the work at the proper instant. This is taken care of by having a central sleeve *L* driven from the gear *F* through gears *O* and *M*. The lower end of this sleeve *L* is made eccentric as indicated at *N* where it will be noticed that one side of the sleeve is thicker than the other. Now, the outer sleeve *C* driving the head *B*, is revolving at a certain speed through its train of gears *D*, *E*, *F* and *G;* similarly eccentric *N* is revolving at a certain speed through its train *M*, *O*, *F* and *G*. If the gears *M*, *O*, *E* and *D* are all of the same size, the relative angular velocity of eccentric *N* and head *B* would be zero. So, in order to give the eccentric a slight relative movement, the gear *M* is given one more tooth than gears *E* and *D*, making its motion a little slower than that of gear *D*. This makes the eccentric lag behind the roller head, drawing in and out the rollers, the movement of the head on sleeve *C* being provided for by the radial keyway between *B* and *C* which was mentioned before.

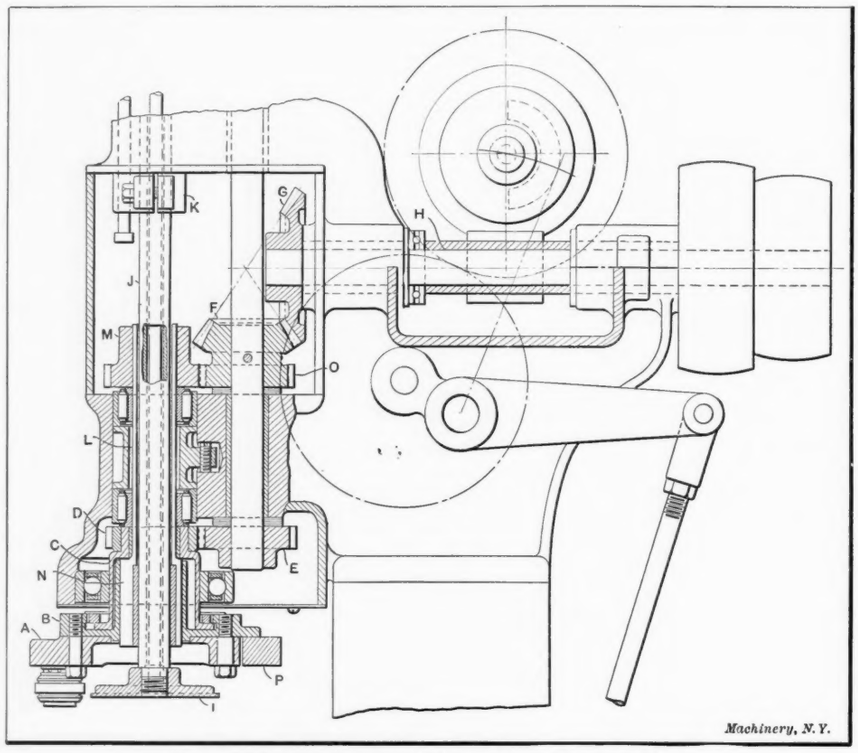


Fig. 4. Head of the Revolving-head Double-seaming Can Machine

It will be noticed that all bearings are either of the ball or roller type, making a very smoothly operating machine. On account of the high speeds of revolution of the roller head, the latter is counterbalanced by a weight *P* opposite the rollers. It will also be noticed that the rollers are double ended so that they may be turned end for end as the spinning grooves wear out. These grooves are of special design and have to be given an exact curvature depending upon the weights of the material to be seamed. The central pin on which the roller revolves is held in an eccentric bushing so that it may be given a certain amount of adjustment to provide for the correct degree of pressure to be applied to the form of the can.

Stationary-head Double-seaming Machine

The construction of the seaming head of the double-seaming machine is somewhat different from that of the revolving-head type previously described. The assembled machine is shown in Fig. 3, while Fig. 5 shows the main details of the head. As the name implies, the seaming head is stationary while the can revolves around in front of the rollers, these rollers being given an in-and-out motion by an eccentric operating in unison with the revolving can. The can, being held up against plate *A* by pressure from below, is driven by spindle *B* through bevel gears *D* and *C* from the main drive shaft *E*. The rollers are held as in the former case on pins in the seaming ring *F*, which is bolted to head *G*. This head *G* is guided by means of a radial keyway in sleeve *H* which is held stationary by cap *I*. A sleeve, the lower end of which is eccentric at *K*, gives the motion to the rollers, and is driven from gears *L* and *M* through the worm gear *N* from the shaft *O*, which derives its power from pulley *P* driven from pulley *Q* on the main drive shaft *E*. By means of a friction arrangement, the drive, instead of being direct from *P* to *O*, is transmitted through a friction disk *R*. Pulley *P*, which is free to slide on shaft *O*, is engaged with disk *R* by a lever that is operated by the spring shown, when a foot-lever is released.

The illustration of the head also shows the arrangement adopted for automatically clamping the can between the chuck-plate and base-plate. The lower base-plate is similar to the upper one shown at *A* with the exception that it is mounted on a shaft, which is vertically adjustable as shall be explained. Gear *S*, keyed to *L*, drives gear *T* which runs

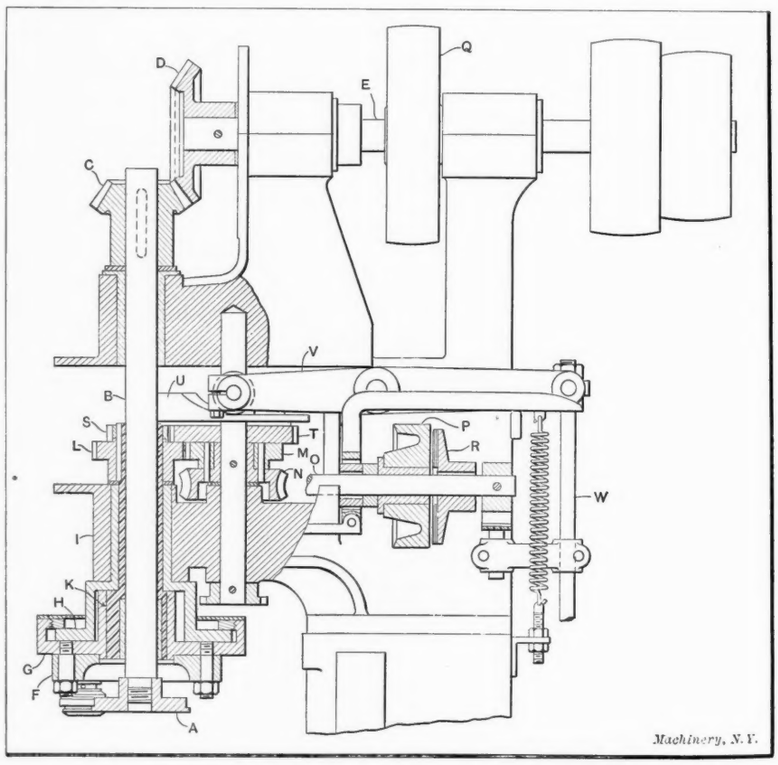


Fig. 5. Head of Stationary-head Double-seaming Can Machine

free on the same shaft as gears *M* and *N*. This gear *T* has keyed to it a cam *U*. A lever *V* fulcrumed near its center is connected through rod *W* to a similar lever below which actuates the lower base-plate as the roller on the inner end of lever *V* rises on the cam. As the mechanism for controlling the rollers and that for lifting the base-plate and can are geared together, they act in unison, successively pressing the can against the chuck-plate, seaming and releasing, the relative adjustments of the different operations being so set as to accommodate these successive movements at the correct instant.

Can-feeding Arrangement

The feeding mechanism for both types of machines is shown in Fig. 6. Cans placed on the outer end of table *A* are fed forward to a certain point by a chain shown in the half-tones. At this point the cans are grasped by the feeding mechanism and fed forward into location between the spinning plates, the one being pushed into location shoving off the completed can at the far end. The mechanism is very simple. The crank *B* is driven in the direction indicated, from a shaft geared to the main drive shaft through the clutch arrangement shown in Fig. 7, which will be explained later. The crank as it revolves carries forward a crosshead, the latter sliding on the ways *H*. The end of the connection-rod *D* has a plate *E* bolted to it, and this plate, in turn, has a minor connecting-rod *F* joining it to the bellcrank *G*. This crank is fulcrumed on a carriage which is free to slide along the ways *H;* the lower arm of the bellcrank actuates the two bifurcated rods *J* clamped to sleeves *K* which slide on the before-mentioned ways *H*. These sleeves and the main carriage are so fixed with regard to each other as to have no relative longitudinal motion. On the same sleeve *K*, are clamped the can gripping arms *L*, the lower ends of which have formed jaws to grip the cans.

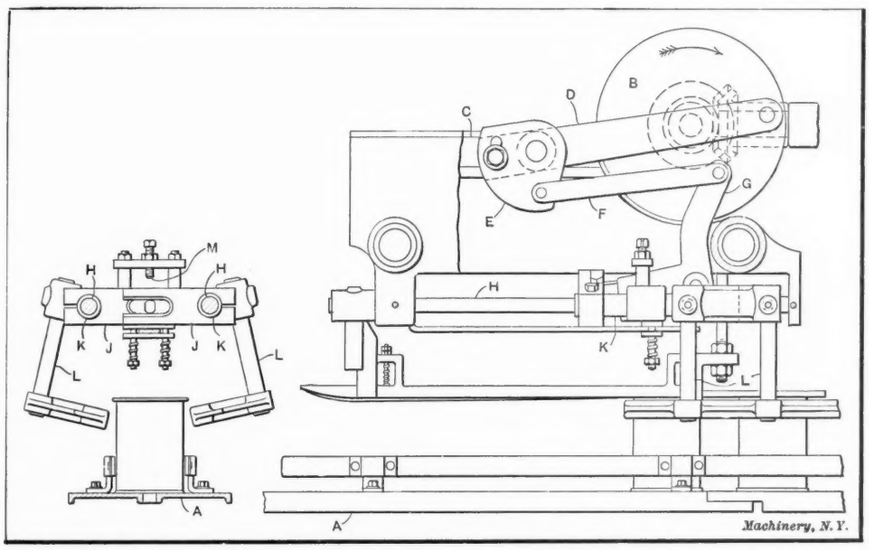


Fig. 6. Automatic Can-feeding Mechanism

Consider the operation of the mechanism with the crank *B* revolving in the direction indicated. As the crank-pin passes below the center, the bellcrank will turn counter-clockwise, forcing down the bifurcated arms *J* into the horizontal position shown in the end elevation; at this point a stop prevents further downward motion, causing the clamp jaws to remain open. The upper end of the bellcrank continuing to the left, forces the whole carriage with it stopping in the extreme left position. Motion is there reversed, the clamp jaws first closing in on the cans, being prevented from gripping them too tightly by the bellcrank arm striking stop *M*. The carriage then moves to the right, carrying three cans forward, placing the forward one in its correct location to be seamed. When the jaws withdraw and recede, the operation is again repeated. In order that the machine may be used with either an automatic or hand feed, it is necessary that the automatic feature be arranged in such a manner that it may be disengaged at will; likewise as it must be operative at the exact point of the circular operations there must be just one point of engagement between the drive and feed mechanism. This is provided for by a one-jaw clutch. Also, in order that no damage might be done by a can sticking on being fed forward, the drive for the latter must be provided with a safety device consisting of a shearing-pin connection of a type well known to most mechanics.

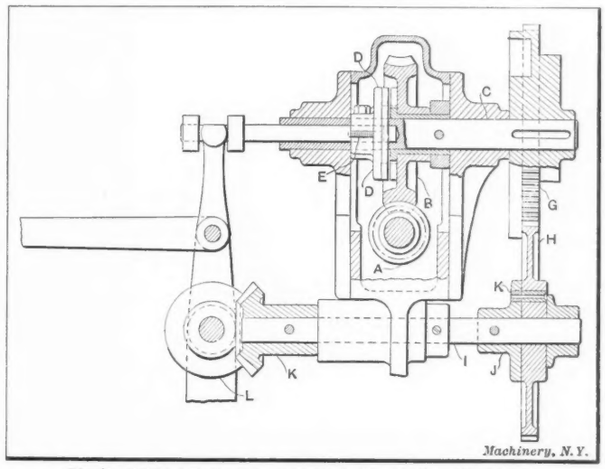


Fig. 7. Driving Part of the Automatic Can-feeding Mechanism

This drive with safety device is shown in Fig. 7. *A* represents a worm on the main drive shaft, meshing with the worm gear *B*, which is free to turn on a bushing on cross shaft *C*. A one-jawed clutch *D* (*i. e.*, a clutch that has only one place of engagement in a complete revolution of the worm gear *B*), is secured to a sliding shaft which enters shaft *C* and is driven by the latter through worm-gear *B* when engaged with it. The shaft has a slot which allows lengthwise movement of the clutch in it. A movement of the sliding rod to the right or left by means of its levers, respectively engages or disengages the clutch. Power is transmitted through shaft *C* to gear *G* and thus to gear *H*. This gear is free on the shaft and it is in it that the safety arrangement is provided. A collar *J* pinned to the shaft has a hardened steel bushing inserted at *K*, while the gear *H* has a corresponding bushing. A thin wire nail inserted in the registered holes of the bushings transmits the necessary power, and should anything obstruct the mechanism, this pin shears off, freeing the machine from breakage. The drive is transmitted by shaft *I* to bevel gears *K* and *L*, the latter being on the same shaft as crank *B* in Fig. 6. The operation of the machine is automatic throughout, and the successive operations are so timed that about three-eighths of the cycle is consumed in actual chucking and machining work, and the balance of the time in feeding the cans forward.

* * *

Some time ago experiments were conducted in the United States in order to ascertain to what extent coal stored under water retained its combustible qualities as compared with coal stored in the air. It was found that the saving from storing coal under water was comparatively small. Experiments have now been made in Germany which verify the American experiments. In this case samples were analyzed after two weeks, three weeks, and six months. These experiments indicated that but little is gained by keeping coal under water or in special atmospheres, such as carbon dioxide, flue gases or sulphurous acid vapors.

TITANIUM STEEL

By E. F. LAKE*

Titanium is one of the elements that have been successfully used to improve the quality of steels. It has also been very successfully used for cast iron and for some of the non-ferrous metals. The first heat of titanium steel made in America was poured in 1907, and since that time a great deal of investigation and experimentation has been conducted. These tests have shown that when ferro-titanium has been added to steel or iron in very small quantities, it has greatly strengthened these metals and improved their qualities in other ways; it can now be considered one of the best of purifying elements that have been used in the manufacture of steel.

Titanium belongs to the same chemical group as silicon, and three other elements that are quite rare. It forms a compound with oxygen, called titanium dioxide (TiO_2), occurring in nature in three distinct forms, the principal one being the titaniferous iron ore so often encountered. In some

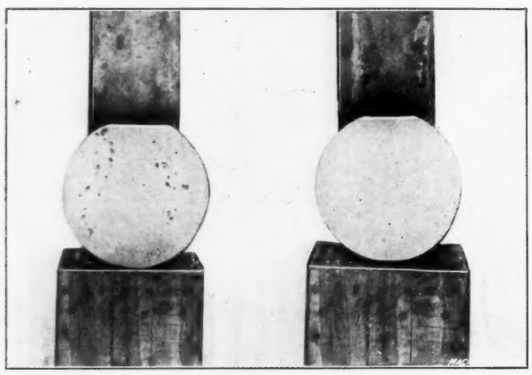


Fig. 1. Blow-holes removed from Cast Iron by Titanium

respects it resembles carbon. Like many of the other elements, it is very difficult to control and make use of when a natural ingredient of the iron ores; it is therefore necessary to separate it in the electric furnace and manufacture it into ferro-titanium containing from 12 to 15 per cent titanium, about 6 per cent of carbon and 5 per cent of all other impurities, with the balance iron. This, when correctly added to steel or iron, can be made very beneficial. With this percentage of titanium, it enters into almost instant solution; but as titanium has a much higher melting point than iron, a higher percentage would cause the titanium to segregate and no beneficial results would be obtained.

While nickel, chromium, molybdenum and tungsten add certain good qualities to steel, none of these combines with nitrogen, thus removing it from the metal, in the way titanium does. Its combination with nitrogen gas is attended with the evolution of heat, and it is the only undisputed example of the combustion of an element in nitrogen. When heated in oxygen it creates an instantaneous dazzling flame.

That oxygen and nitrogen are very injurious to steel and decrease its strength, wearing qualities, etc., is now a recognized fact; that these elements are present in larger quantities than has been previously supposed is also recognized. When titanium is added to the molten metal, it combines with these gases, which otherwise are liable to become occluded in the steel and carries them off into the slag. These gases also form miniature bubbles that, when segregated, form holes large enough to be plainly seen. If segregated in large enough masses they form good-sized blow-holes.

Oxide forms when oxygen comes in contact with iron, and is present in very small black specks throughout the steel. This oxide can only be seen when the surface has been perfectly polished and magnified at least 1000 times. It is invariably found in steels that produce blisters when pickling, and this leads to the conclusion that the blisters are formed by the reduction of oxide by the nascent hydrogen evolved during the pickling process. High-carbon steel rods that contain the same impurities occasionally fracture in the pickling bath, and doubtless the same pressure that blows a blister in mild steel will cause a rupture in hard steel.

* Address: 184 Ave. B, cor. 47th St., Bayonne, N. J.

Owing to the gaseous nature of both oxygen and nitrogen, it has been difficult to analyze steels for these contents. Some recent investigations, however, showed that the percentage of oxygen in some twenty-four samples of steel ranged from 0.021 to 0.046 per cent. These percentages may seem to be so extremely small that they could be ignored. But the amount of an element present, however, should not alone be considered, when judging its influence on steel; the combinations that the element forms should be taken into consideration. When mention is made of 0.05 per cent of sulphur, it is in reality the 0.13 per cent of manganese sulphide that affects the quality of the metal. Oxygen has only half the atomic weight of sulphur and is capable of forming larger quantities of compounds; therefore, it exerts a greater influence. Thus where 0.05 per cent of sulphur corresponds to 0.13 per cent of manganese sulphide, 0.05 per cent of oxygen corresponds to 0.22 per cent of ferrous-oxide. This percentage is therefore high enough to very materially affect the qualities of steel.

It was shown by some recent investigations that at first an increase of nitrogen causes the toughness of steel to slightly increase, but reduces its ductility; each increase of nitrogen causes the elongation to rapidly diminish. When the nitrogen content reaches 0.030 to 0.035 per cent, there is, practically speaking, no further elasticity and the metal becomes absolutely brittle. Steel with 0.5 per cent carbon loses its ductility in the presence of 0.040 to 0.047 per cent of nitrogen. In a one per cent carbon steel, the elongation and contraction become nil when the nitrogen content reaches 0.03 to 0.035 per cent. In the softer steels, this happens when the nitrogen content reaches 0.05 to 0.065 per cent, and in the very soft steels, with about 0.08 per cent of nitrogen.

Open-hearth steel usually contains from 0.020 to 0.025 per cent of nitrogen; Bessemer steel from 0.018 to 0.062 per cent; and crucible steel runs from 0.010 to 0.015 per cent in nitrogen. Thus, a nitrogen content of at least 0.012 per cent must nearly always be reckoned with. Steels made in the resistance electric furnace are an exception to this, as they are practically free from nitrogen. Steels, however, that are made in the arc electric furnaces, in the presence of basic slags, are liable to contain injurious amounts of nitrogen.

Titanium has a very strong affinity for both oxygen and nitrogen; it forms with oxygen an oxide, and with nitrogen, a stable nitride that shows as tiny red crystals under the microscope. Both of these are then carried off into the slag

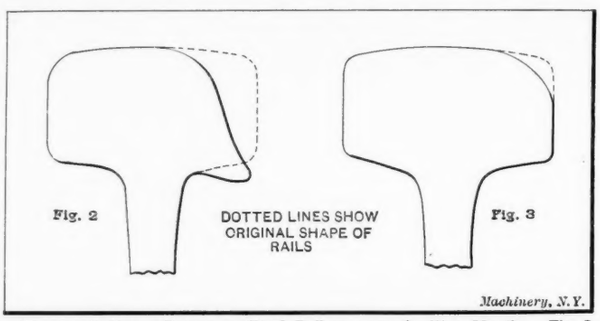


Fig. 2. Ordinary Bessemer Steel Rail as worn in Nine Months. Fig. 3. Titanium-treated Bessemer Steel Rail as worn in Nine Months on the Same Curve

and the quantity of slag that is lifted from the molten metal is quite materially increased. The deoxidation of steel is usually accomplished with manganese and silicon, but these never remove the oxides and occluded gases as thoroughly as is desired. Titanium is a much more powerful deoxidizer than either or both of these; when added to steel at the time of tapping, it completes their unfinished work and reduces the oxygen and nitrogen to mere traces. If a greater amount of titanium is used than is needed to remove the oxides and nitrides, it will afterward attack the sulphur and phosphorus and if it does not remove them, it counteracts their injurious effects upon the steel. The phosphorus may be made to pass into the slag as phosphate of titanium by using special means. The reaction of titanium on the sulphur has a tendency to carry it off in the form of a sulphide or sulpho-cyanide of titanium. Cupro-ammonium etching tests show the low sulphur and phosphorus content of titanium treated steel.

The very energetic reaction of the titanium and nitrogen takes place at a temperature of about 1475 degrees F. The good effects of their union can easily be lessened by a careless shutting off of air, thus permitting the formation of titanium and nitrogen combinations that are of no value.

How easily nitrogen finds its way into steel is shown by a heat of Bessemer steel that had been over-blown three minutes. This was found to contain 0.032 per cent of nitrogen, whereas the normal steel contained only from 0.012 to 0.022 per cent. Another heat of Bessemer steel containing from 0.013 to 0.014 per cent of nitrogen was treated with one per cent of titanium and this reduced the nitrogen to from 0.004 to 0.005 per cent.

When possible, it is always best to add the ferro-titanium to the steel while it is being tapped into the ladle, and after the ferro-manganese has been added. It is lighter than iron and would not sink and disseminate if it were added near the top; hence, it should be shoveled in gradually while the steel is flowing into the ladle. Titanium treated steels should be held in the ladle for from 5 to 15 minutes before pouring, in order to allow the titanium to do its work and scavenge out the oxygen and nitrogen. It is difficult to influence steel makers to hold the steel that long in the ladle, as without the titanium it would become chilled in a much shorter time. Titanium, however, raises the temperature and the metal is in better condition for pouring after standing than before.

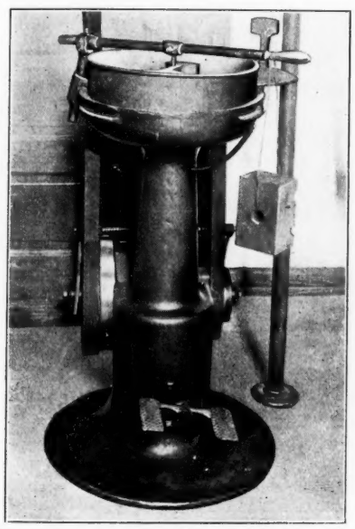


Fig. 4. Testing Rail Section for Abrasive Wear, in a Special Machine

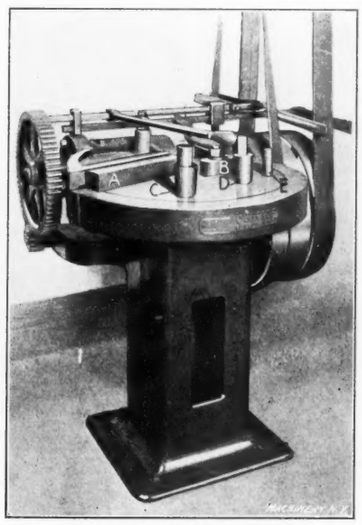


Fig. 5. Machine for Making Bending Test on Titanium-steel Bars

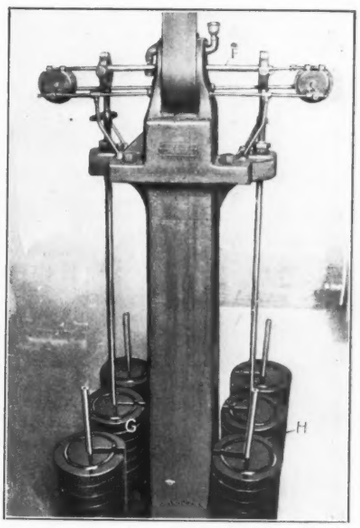


Fig. 6. Testing Endurance of Titanium Steel in a White-Souther Rotary Vibrational Testing Machine

Owing to an accident, one ladle had to be held 20 minutes after tapping and adding the titanium and it was then found to be in better condition for teeming into ingots than the ordinary steel that is teemed as soon as the ladle is filled. This is a statement that is very difficult to make steel makers believe; but the evidence is very conclusive and can easily be obtained.

When commencing the use of titanium, one per cent should be added to the bath; this can gradually be reduced until the beneficial results obtained reach the high point and begin to diminish. In most cases one-half of one per cent is all that can be made to benefit the metal. In manufacturing Bessemer steel rails, this latter percentage only increases their cost about $1.50 per ton. It is antagonistic to aluminum and the two should never be used together, for aluminum adds brittleness to steel, while titanium removes brittleness.

By removing the oxygen and nitrogen, titanium prevents the formation of blow-holes in steel. This is well illustrated by the two pieces shown in Fig. 1. The one containing blow-holes was cast without any titanium, while the piece without blow-holes was cast from the same metal after 0.5 per cent of titanium had been added. The reaction of the titanium raises the temperature of the bath and makes it more liquid by freeing it from the free oxide and slag. This allows the metal to subside in the mold while cooling and the pipe is smaller and flatter. The metal invariably lies dead in the ingot molds and does not boil. By removing the occluded gases and slag from steel, titanium increases the density of the metal and retards any tendency towards segregation, thus making a much more homogeneous metal. It also increases the tensile strength, elastic limit, contraction, transverse strength and ductility of steel. It greatly improves its resistance to frictional or abrasive wear, and resistance to shock, torsional and impact strains.

Tests of Titanium Steel

One example of its ability to withstand torsional strains was obtained by twisting through seven complete revolutions, a bar four feet long and one and one-eighth inch square; there was no sign of a fracture. The Brinell hardness test shows a titanium treated steel to be softer than one not treated with titanium, and this is doubtless due to the finely divided ferrite net-work.

One recent test of some structural steel showed that before it was treated with titanium, it had a tensile strength of 67,000 pounds per square inch and an elastic limit of 42,000 pounds, the elongation being 24 per cent and the contraction, 40 per cent. After this same metal had been treated with 0.50 per cent of titanium, the tensile strength was 77,120 pounds per square inch, the elastic limit, 51,750 pounds, the elongation, 25 per cent and the contraction, 43 per cent.

Another heat of steel that was rolled into billets and then into iron rods of slightly less than ¼ inch diameter, gave a tensile strength of 114,400 pounds per square inch, an elastic limit of 91,000 pounds per square inch, an elongation of 28 per cent, and a contraction of 52 per cent; ordinarily, 90,000 to 95,000 pounds per square inch is the tensile strength of this metal. This 20 per cent increase in tensile strength was doubtless due to the titanium removing the occluded gases and slag.

The resistance of titanium steel to abrasive or frictional wear is well shown by comparing the steel rails illustrated by Figs. 2 and 3. In Fig. 2 is shown an ordinary Bessemer rail that was laid October 7, 1908, and measured July 8, 1910, to get the shape as shown and thus show the amount of wear. Fig. 3 shows the shape of a titanium treated Bessemer rail that was laid next to that shown in Fig. 2, on the same date and measured on the same date. The ordinary Bessemer rail lost 7.03 pounds per yard during the 9-month wear, while the titanium treated rail only lost 1.39 pound per yard. Another method of testing for abrasive wear is performed with the machine shown in Fig. 4. This shows a section of a steel rail placed upon the top of a revolving plate, coated with abrasives, in the top of the machine, and held down by a lever. On the handle of this lever a block of iron of known weight is hung, as shown.

Titanium treated steels have recently been extensively tried for gears, plates, rolls, tires, castings, etc., and they have almost

invariably shown a reduction of brittleness and an increase of durability. One method of testing this is shown by the machine in Fig. 5. In this test, bar *A* is held in the machine and bent around a 1-, 2- or 3-inch center, as the case may be, located at *B*. Different sized centers are shown at *C*, *D* and *E*.

A steel that contained 0.25 per cent of carbon, 0.30 per cent manganese, 0.40 per cent silicon, 0.04 per cent phosphorus, and 0.03 per cent of sulphur, would frequently crack in many directions when forged under a hammer at a bright red heat. When this same steel was treated with 0.030 per cent of titanium it worked down smoothly and evenly without a flaw. Good results might be obtained if the manganese and silicon were reduced by nearly 50 per cent and the sulphur and phosphorus slightly increased.

The endurance of titanium treated steel has been well demonstrated by tests that were given it on the White-Souther rotary vibrational testing machine shown in Fig. 6. An open-hearth steel that contained 0.25 per cent carbon, 0.64 per cent manganese, 0.425 per cent silicon, 0.04 per cent phosphorus, and 0.035 per cent sulphur, withstood 2,660,000 revolutions at a fiber stress of 38,870 pounds. After this same steel had been treated with titanium, it was given 4,052,200 revolutions at the same fiber stress, namely, 38,870 pounds. The stress was then increased to 40,600 pounds and the piece stood 10,800,700 additional revolutions without a fracture. The fiber stress was again increased to 42,400 pounds and the piece given 1,918,600 more revolutions. The stress was increased a third time to 44,200 pounds and the piece was given an additional 1,006,300 revolutions before it broke. This was a total of 18,274,900 revolutions for the titanium steel, many of which were given it at an increase of fiber stress, as against 2,660,000 revolutions of the untreated steel.

For these tests a bar is placed in the machine as shown at *F*, and revolved by the belt and pulley while the weights located at *G* and *H* give it the fiber stress. As it is well known that iron is ductile in proportion to its purity, this increase in rotary vibrational strains can only be attributed to the purifying properties of the titanium which by removing the oxygen, nitrogen, etc., increases the cohesive force between the molecules and makes the steel more homogeneous. In increasing the ductility it does not soften the metal enough to weaken it, but on the contrary increases its strength. By removing the occluded gases and other impurities it also increases the resistance of the steel to corrosion.

Alternating vibrational strains are given the metal by the machine shown in Fig. 7. In this the test piece is held at *I* while the part of the machine shown at *J* is rocked back and forth to alternately bend the sample ¼ inch either way from the vertical. This also has given some very good results for titanium steel. Both machines have a cyclometer attached to register the number of revolutions or alternations given the sample.

Impact tests are given the steel by the machine shown in Fig. 8. In this, only the lower part of the machine could be shown, as it passes through the floor. The upper part is only a guide for the weight and, in this machine, extends 20 feet above the platen. The test piece is placed on platen *K*, and weight *L* is dropped on it, from a given height. When weight *L* strikes the test piece, the springs under platen *K* give, and pointer *N* registers the foot-pounds of the blow, on dial *M*.

Some tests on titanium treated steel rails that were 85 pounds to the yard, were conducted in a similar way. Rails were cut up into 3-foot 6-inch lengths, laid on supports three feet apart, and a weight of 2000 pounds dropped on them from a height of 17 feet. Three blows were given on the head and the deflection measured. Then the rail was turned over and the fourth and fifth blows were given on the base. Table I gives the results of these tests.

Titanium in Tool Steels

Titanium treated steel can be made by the crucible process and only increases the cost of the metal $2.50 per ton when one per cent of titanium is used. This, with the properties given steel by titanium, caused some experiments and tests to be conducted on tool steels in Sheffield, England. In these, enough titanium was used to give 0.25 per cent and 0.35 per cent of the titanium in the finished steel. An ordinary tool steel with a tensile strength of 127,000 pounds per square inch was used. Six lathe tools were made from it before the titanium was used. The metal was then treated with titanium and six more tools made. One tool with titanium and one without turned the same bar at the same time. Thus tools 1 and 3, 5 and 7, and 9 and 11 were used together and

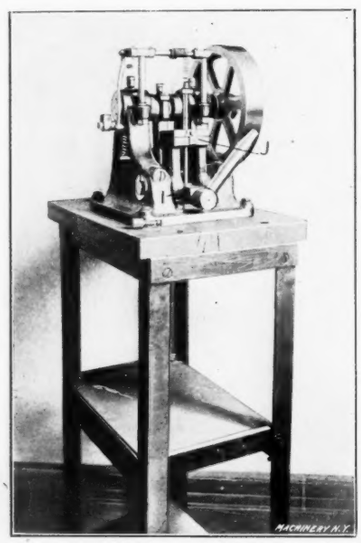


Fig. 7. Testing Titanium Steel by subjecting it to Alternating Vibrational Strains

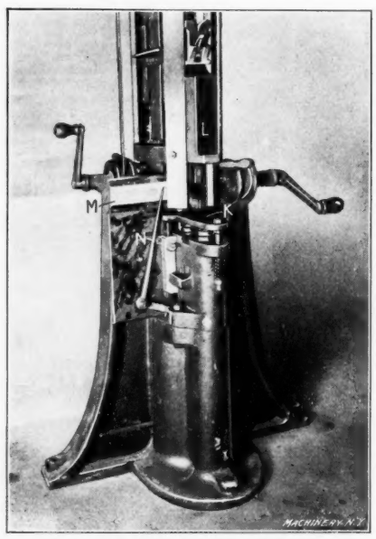


Fig. 8. Machine for giving Impact Tests to Steel

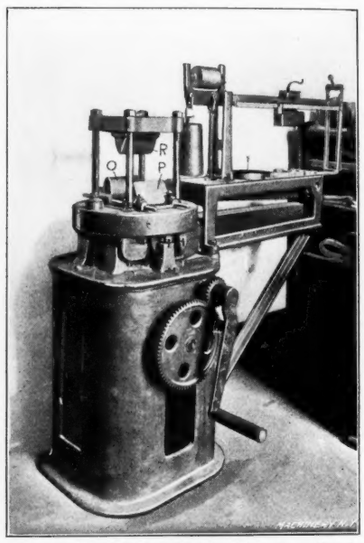


Fig. 9. Machine for Testing the Strength of Titanium-treated Cast Iron

TABLE I. DROP TESTS OF RAILS

Number of Drop				
1	2	3	4	5
Deflection in Inches			Condition	
1.3	2.5	3.5	Straight	Broke
1.4	2.5	3.6	Straight	Broke
1.4	2.6	3.9	Straight	Broke
1.5	2.7	4.0	Bent other way	As before
1.5	2.1	4.1	Straight	Broke
1.5	2.1	4.1	Broke	.....
1.4	2.7	3.1	Straight	Quite straight
1.4	2.7	4.1	Straight	Broke
1.4	2.2	3.4	Straight	Broke
1.5	2.7	3.9	Straight	Quite straight
1.6	2.9	4.1	Straight	Flange broke
1.6	3.1	4.4	Bent	Flange broke
1.6	3.1	4.2	Bent	Flange broke

tools 2 and 4, 6 and 8, and 10 and 12 were used likewise. The tools were all given the same heat treatment and the results that were obtained are shown in Table II.

In some experiments that were made by tool-steel makers in the Pittsburg district, it was found that if 0.50 per cent of titanium was retained in the steel, it would give cutting tools much greater durability and high-speed qualities. A special method is required, however, to retain any of the titanium in the steel, as its great affinity for oxygen and nitrogen causes it to go off into the slag. By removing the impurities, the titanium causes the metal to heat more slowly in the forge and also to retain the heat longer after it has been worked and become cold. This property of heating more slowly

TABLE II. TURNING TESTS WITH TOOL STEEL

Number of Tool	Titanium Content, Per Cent	Depth of Cut in Inches	Width of Chip in Inches	Speed in Feet per Minute	Minutes Tool was Used	Condition of Tool at End
1	None	$\frac{1}{64}$	$\frac{1}{4}$	27	70.0	Blunt
2	None	$\frac{1}{64}$	$\frac{1}{4}$	27	71.5	Blunt
3	0.25	$\frac{1}{64}$	$\frac{1}{4}$	27	109.2	Blunt
4	0.35	$\frac{1}{64}$	$\frac{1}{4}$	27	117.2	Blunt
5	None	$\frac{1}{64}$	$\frac{1}{5}$	32	28.2	Blunt
6	None	$\frac{1}{64}$	$\frac{1}{5}$	32	42.8	Blunt
7	0.25	$\frac{1}{64}$	$\frac{1}{5}$	32	63.3	Blunt
8	0.35	$\frac{1}{64}$	$\frac{1}{5}$	32	76.4	Blunt
9	None	$\frac{1}{64}$	$\frac{3}{32}$	50	25.4	Blunt
10	None	$\frac{1}{64}$	$\frac{3}{32}$	50	70.6	Blunt
11	0.25	$\frac{1}{64}$	$\frac{3}{32}$	50	97.2	Blunt
12	0.35	$\frac{1}{64}$	$\frac{3}{32}$	50	133.2	Blunt

causes the cutting edge to last longer, as the temper is retained longer. The resistance to corrosion will also keep the tools from rusting as readily when laid away.

As steel treated with titanium shows greater resistance to abrasive and frictional wear, it heats up more slowly from friction. Thus whether it be the tool or the work that is treated with titanium, the machine work can be performed more quickly, as the cutting speed can be increased; whether the tools be of the carbon or high-speed kind, makes no difference about increasing the speed. One instance of the slow heating of titanium treated metal was shown in some ingot molds that did not show red in the dark when filled with molten metal; whereas ordinary ingot molds filled at the

TABLE III. TESTS OF GRAY IRON CASTINGS WITH AND WITHOUT TITANIUM

Without Titanium			With 0.5 Per Cent of Titanium		
Sample	Crushing Strength in Pounds	Deflection in Inches	Sample	Crushing Strength in Pounds	Deflection in Inches
1	2,240	0.10	1	3,050	0.09
2	2,260	0.10	2	3,140	0.10
3	2,010	0.09	3	3,150	0.10
4	1,840	0.08	4	3,230	0.10
5	1,970	0.08	5	2,850	0.10
6	2,150	0.10	6	2,990	0.09
Average	2,078	0.09	.....	3,068	0.10

same time and standing beside them, were distinctly red hot.

Steel castings that have been treated with titanium are more blue in color, freer from blow-holes and brittleness and heat up more slowly from cutting tools than ordinary steel castings; they can thus be machined more easily and rapidly.

The No. 3 Government specifications for cast steel have been difficult to meet without resorting to several heat treatments. They call for a tensile strength of 85,000 pounds per square inch, an elastic limit of 45,000 pounds per square inch, an elongation after rupture of 12 per cent, and a contraction of 18 per cent. By the use of 8 pounds of the 10 to 15 per cent ferro-titanium to a ton of metal, the difficulties have been overcome by one foundry.

In fifteen heats before the titanium was used, the average tensile strength of castings after the first annealing was 81,633 pounds per square inch, the elastic limit was 47,233 pounds per square inch, the elongation 15.1 per cent and the contraction 18.9 per cent.

The fifteen heats after this, that contained titanium, produced castings with an average tensile strength of 91,533 pounds per square inch, an elastic limit of 50,000 pounds per square inch, an elongation of 19.2 per cent, and a contraction of 24.3 per cent. The steel that entered into the castings was made in a Tropenas converter, and was free from blow-holes, homogeneous, and very uniform in its properties.

Very exhaustive tests have been made of the effect of titanium in cast iron and Table III shows the comparison between gray iron as cast without titanium and with 0.5 per cent of titanium added. These tests were made in the machine shown in Fig. 9. The test bar is laid on the supports *O* and *P* while block *R* is forced down on it. The deflection and number of pounds required to break the piece are then measured.

The transverse strength has been increased from 17 to 23 per cent by the use of titanium. It also increases the breaking strains, wearing qualities and hardness in the chill of cast iron; but it decreases the chilling effect.

* * *

INDUSTRIAL CONDITIONS IN SWEDEN

The industrial development in Sweden during the last decade has been very remarkable, and reminds one rather of the booms of the West than of the slow and normal development of an old country. Hydraulic power plants have been built in great numbers, and the industries furnishing the machinery and equipment to these plants have been steadily engaged. The Swedish firms making water turbines and electrical machinery have a high reputation for the quality of their product, and the requirements of the country in these branches are largely met by the local firms. The general industrial development has, of course, had a favorable influence on the machine tool trade, and as the country does not supply the demand in this respect, American and German machine tools have been sold to a considerable extent. The only class of machine tools built in the country in sufficient quantities to meet the demand is lathes, and these are built of such high quality that competition is very difficult. The demand for small tools is also largely met by the manufacturers in Sweden. Milling machines and grinders are the machine tools for which there is the most promising market, and a considerable number of the leading American machines of these classes are seen in the Swedish shops.

Unfortunately, the boom has been somewhat overdone, and in many instances, the past year was not a prosperous one for the Swedish machine shops. This, however, was frequently due to mismanagement and a lack of understanding, on the part of those in authority, of the requirements of modern efficiency in shop practice. Only a few Swedish firms have as yet understood that the secret of success is a specialized manufacture. One large plant builds internal combustion engines, steam engines, boilers, wood-working machinery, kitchen ranges and heaters, and a few other "specialties." Swedish engineers who have received a few years' practical training in American factories are in charge of many of the best shops, and the influence of their American training is clearly in evidence. This, coupled with their native mechanical inclinations, results in a high standard of engineering.

* * *

At the beginning of this year there were about 3000 passenger cars in service in this country, built of all steel construction. The total number of passenger coaches is about 54,600 so that the number of steel cars is about 5.3 per cent of the total. Of the cars constructed during the present year, 62 per cent will be all-steel construction, so that at the end of this year fully 9.3 per cent of all passenger cars will be of steel, while 3.5 per cent have steel under-frames. The percentage of wooden cars in service has dropped in the last three years from 98.2 to 87.2 per cent. According to an estimate in the *Railway Age Gazette*, the cost of replacing all the present wooden cars with steel cars, which has been advocated in some quarters where apparently the magnitude of this undertaking is not fully understood, is estimated at about $630,000,000.

JOINING TIN BY FOLDED SEAMS*

The folding-over process is one of the elementary methods of joining pieces of tin, especially as used in cans; riveting is not satisfactory for this purpose, as it does not hold the pieces in close contact. To overcome this difficulty, the overlapped parts are often soldered; and to make this soldering more effectual, the edges are usually bent over to form a fold. Three classes of joints are formed by this folding-over process—those running lengthwise of cylindrical bodies or frames of tin made from one piece, those formed where the bottom or top of a can is joined to the main body, and finally those formed by a spinning operation on the contact edges of cylindrical bodies.

We will consider first the longitudinal seam: Suppose it is desired to form the body of a four-cornered can, such as that shown at *A*, Fig. 1. The stock is bent around a mandrel to the shape indicated, forming the four corners and overlapping the two edges as shown. This part of the process may be done automatically in modern machines. When the edges overlap, as in this case, they may be clamped securely in one position and the solder applied, but this is a rather tedious process. The most objectionable feature of this method is that the edges of the tin tend to spring apart, requiring to be clamped during the soldering. It is therefore better

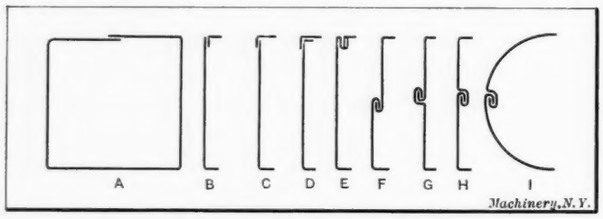


Fig. 1. Types of Longitudinal Seams

to put the seam at the corner, as indicated at *B*, but even then the edges have a tendency to slip, notwithstanding the use of clamps. Reversing the relative positions of the lapping edges as at *C*, largely obviates this springing effect, but does not form a neat seam. Therefore, if a neat job is desired, it is advisable to bend both edges as at *D*. In this case the soldering surface is much greater, and in addition, one edge of the seam is invisible. Forming as at *E*, makes a seam that is even less noticeable. Here the solder works into all parts and a very good seam is produced. This double bend may be made in one of the sides, but it has the objectionable feature of being easily sprung open; the formation of a double bend in the side is shown at *F*. To overcome this tendency to spring apart, both bends may be slightly depressed as at *G*, which brings the ridge due to the seam on the outside. At times it is objectionable to have the seam on the outside so a similar seam may be produced on the inner surface of the can, as at *H*. The same type of seam may be

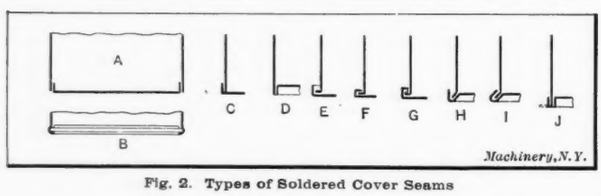


Fig. 2. Types of Soldered Cover Seams

applied to circular cans, as indicated at *I*. In the latter case the process may be carried on by automatic machinery; in fact, there is a patented machine in Germany at present, which will produce upward of 30,000 seams in a ten-hour day.

The second type of seam referred to is that which joins the cover to the body of a can; this is illustrated in Fig. 2. It is not customary to solder the cover to the body of the can edge to edge, in the rough state; one edge at least should be bent to form a soldering surface. In Fig. 2 at *A* is shown a cover with its edge bent upward to fit into the body of the can, thus forming a soldering surface. When the bottom of the can is made of especially strong stock, it is possible to join it to the body by pressing the body down over the end after the bottom has been fitted into the body as at *B*. A method similar to that shown at *A* is indicated at *C*, where the upturned edge of the cover is outside of the can body; this is quite a common construction, but it is objectionable in many cases because the bottom is resting on the surface, whereas with a construction such as shown at *D*, the bottom rests on a rim. This latter construction is particularly advantageous for riveting purposes, being much better than that shown at *C*.

The double flare shown at *E* was used to a considerable extent formerly, assuming the shape shown at *F* when sealed. The latter form is obtained by bending over the upturned

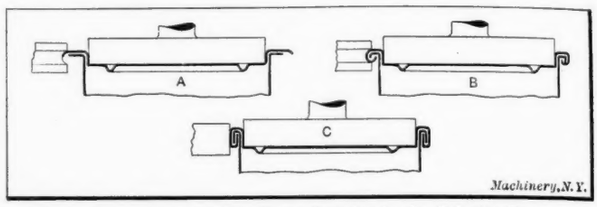


Fig. 3. Successive Stages in Cover Seaming by the Spinning Process

edge of the cover in a machine, or else by hammering the rim. This construction is not practicable, however, for all receptacles, so for that reason it is modified to the form shown at *G* with the double seam bent back against the body of the can.

Conical flares, such as those shown at *H* and *I*, are often made. *I* shows the seam closed by bending the upturned edge of the cover back against the conical flare of the body. This is done between two rollers.

When joining very thin pieces of tin, seams are made by spinning as indicated in Fig 3, the successive steps being shown at *A*, *B* and *C*. Grooved rollers of the proper shape spin the metal, forming the seam. This forms such a tight joint that solder is unnecessary, but in most cases the contact surfaces are spread with a thin emulsion or fluid of

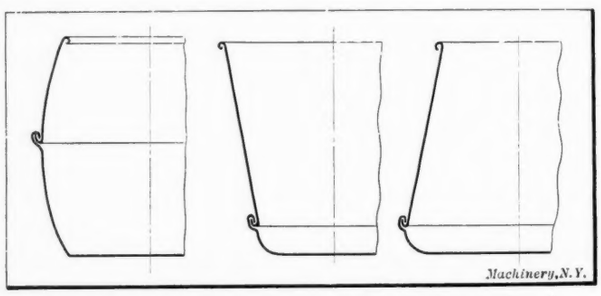


Fig. 4. Types of Bodies that can be joined by the Spinning Process

an organic nature which fills any crevices that may still exist. These seams are usually made, as indicated in Fig. 3, by placing the can and cover vertically between two rapidly revolving disks which rotate it, during which movement the rollers perform their functions.

During this seaming process, can bottoms are subjected to strain, and for this reason an annular groove is formed in the cover which takes up any spring due to the pressure of the rollers. Not only is this method of seaming applicable to circular bodies, but it may also be applied to square and oblong bodies. Tin cans of complex or fancy shapes can be made by this seaming process in special presses; they are flared and joined in the usual manner. Such cans are shown in Fig. 4.

In all these methods of joining it must be remembered that at the point where the seams come together a small corner of the body should be removed so that there will not be too many thicknesses of tin at that particular point, otherwise the rollers would tend to skip over these places entirely.

* * *

Sometimes when a man gets restless and wants to make a change and go somewhere else, says one of our contemporaries, all that he needs is a vacation and a rest.

* Abstract of article by A. Bauschlicher in the *Zeitschrift für Werkzeugmaschinen und Werkzeuge.*

MILLING, CROSS-DRILLING AND BURRING ATTACHMENTS*—1

APPLICATION TO THE BROWN & SHARPE AUTOMATIC SCREW MACHINE

By DOUGLAS T. HAMILTON†

The Brown & Sharpe Mfg. Co., Providence, R. I., has designed a number of standard and special attachments for its automatic screw machines. These attachments are used for performing various second operations on a piece of work, such as slotting, milling, cross-drilling and burring, at the same

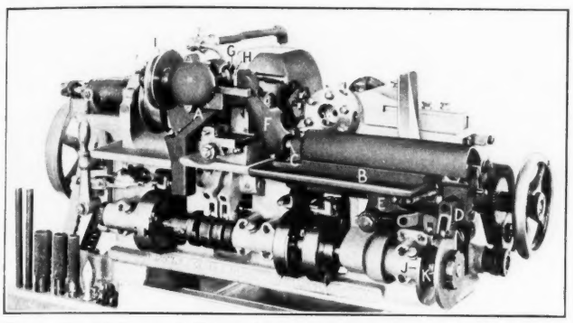


Fig. 1. No. 00 Brown & Sharpe Automatic Screw Machine equipped with a Screw-slotting Attachment

time that another piece is being operated on by the cross-slide and turret tools. Thus extra operations are performed without taking additional time.

While the attachments—as such—are widely known, the methods of laying out the cams for operating them are no doubt unfamiliar to a large number of operators and mechanics in general, and, therefore, a description of the methods of laying out the cams for slotting, cross-drilling and burring should be of general interest. The first and best-known attachment designed by the Brown & Sharpe Mfg. Co. was its screw-slotting attachment, which is shown attached to a No. 00 automatic screw machine in Fig. 1. Assembly views of this attachment are shown in Fig. 2.

* For previous articles on screw machine work, see MACHINERY, January, 1911, "External Cutting Tools."

† Associate Editor of MACHINERY.

Screw-slotting Attachment for the No. 00 Machine

The screw-slotting attachment shown at *A* in Fig. 1 is fastened to a boss, provided for this purpose, on the machine, by two cap-screws. An apron *B*, which is also an additional part, carries the arbor *C* to which the transferring arm *F* is attached. The transferring and advancing cam levers *D* and *E* are also fastened to bosses on this apron by cap-screws as shown. These levers are operated by the advancing and transferring cams *J* and *K*. A block *H* is fastened to the arm *F*, and a slotting bushing or carrier for the screw is driven into it. This bushing grips the screw and holds it while the slotting saw *G*, held on an arbor and driven by a pulley *I* through bevel gears, mills the slot in the head. The pulley *I* is driven by a ⅜-inch round belt from the overhead works.

A clearer idea of the working mechanism of this slotting attachment can be obtained by referring to Fig. 2 where the transferring and advancing cams, as well as the levers operated by them, are more clearly shown. The transferring lever *D* is kept in contact with the cam by means of two springs *L* and *M*. The advancing lever *E* is kept in contact with the advancing cam by the spring *N*, located on the transferring-arm rod *C*. This open-wound spring presses against the boss *O* on the attachment and the washer *P*, this latter being held up against a ball retainer *Q* which, in turn, is forced against a washer held to the arbor *C* by a cone-pointed screw. The lever *E* does not bear directly against the thrust-washer *R* to advance the arm, but holds a set-screw *S* which can be adjusted in and out and locked with a headless screw. This screw *S*, in conjunction with the screw S_1, is used for varying the depth of the slot in the head of the screw.

The transferring lever *D* is connected to a block D_1, which is fastened to the rod *C* by a screw C_1. This block connects arm *F* with lever *D*. The arms of lever *D* and the arm *F* are so proportioned that a small rise of about 1⅛ inch on the cam in this case is sufficient to carry the slotting bushing from the chuck up to the saw through the path indicated in the engraving. When arm *F* drops down into a position in front of the chuck, it is stopped at the desired point by a set-screw E_1, which rests on a block F_1, attached to the machine. When the arm moves up into a position in front of the saw, it is stopped by a set-screw G_1, which bears against

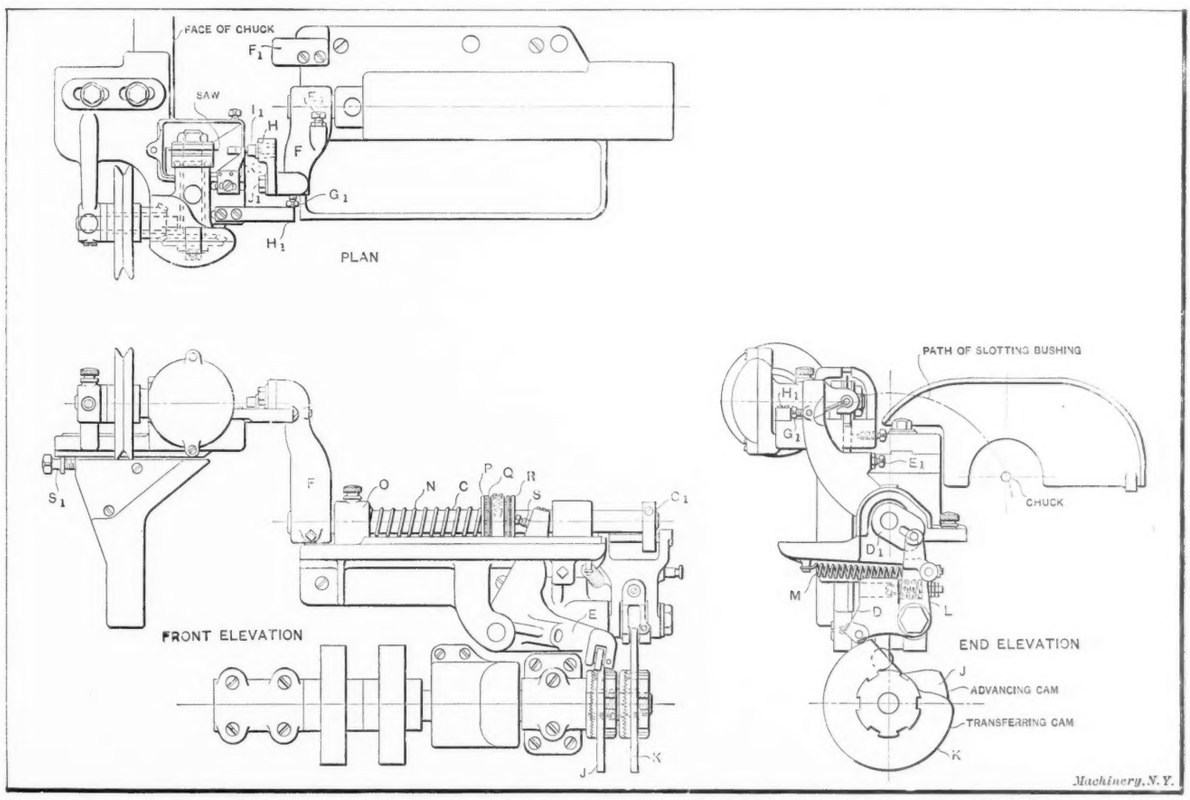


Fig. 2. Assembly Views of the Screw-slotting Attachment for the No. 00 Brown & Sharpe Automatic Screw Machine

a block H_1, fastened to the attachment. The set-screws G_1 and E_1 are used for setting the slotting bushing accurately. The slotting bushing is shown at I_1 in position in block H. The shank of this bushing is tapered one-half inch to the foot and is driven into the block. Block H is held to the arm by a cap-screw J_1. When the slot in the screw has been cut and arm F drops back, the screw is removed from the bushing, which has a slot cut in it, by the ejector K_1, which is simply a piece of sheet steel fastened to the attachment.

Laying Out a Set of Cams for a Screw-slotting Operation

Undoubtedly the method of setting and operating this screw-slotting attachment can best be described by taking a practical example. Suppose it is necessary to make the shouldered steel screw shown at *A* in Fig. 3 on a No. 00 Brown & Sharpe automatic screw machine. To proceed, first design the cross-slide and turret cams, making allowance for one empty hole in the turret, thus enabling the transferring arm to drop down and pick up the screw while it is being cut off. It will not be necessary to describe the method of laying out the turret and cross-slide cams, as this has been described previously,* so we will confine our attention to the calcula-

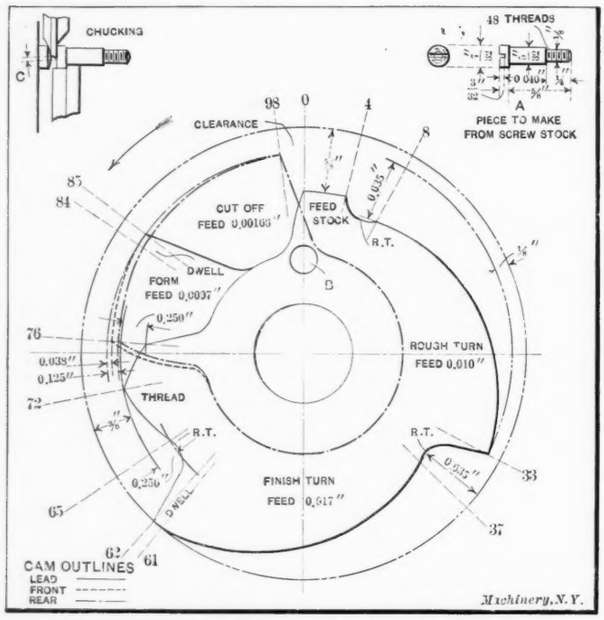


Fig. 3. Turret and Cross-slide Cams for Making a Steel Screw

tions necessary in laying out the transferring and advancing cams for removing and slotting the screw.

Before proceeding with the laying out of these cams, it is necessary to make a diagram such as is shown in Fig. 4. Here a diagrammatical view of the necessary movement of the transferring and advancing levers is shown. To the right of the illustration is a diagram of the movement of the transferring arm and lever. For the slotting attachment, the transferring arm does not have to dwell at any intermediate point between the chuck and the slotting saw, so that no calculation is necessary to find the rise on the cam—the full rise or 1⅛ inch being sufficient to lift the slotting bushing from the chuck to the slotting saw. To the left of the illustration is a diagram in which is indicated the least and greatest possible distances between the face of the turret and the chuck, and also the position of the screw-slotting arbor relative to the chuck. Below this, the transferring arm is shown in position on the screw. Here it can be seen that the lobes for placing the bushing on the work and advancing it to the saw will be of the same height, as the distance 3/32 inch is considerably less than the adjustment provided for the screw-slotting attachment; this adjustment is equal to 5/16 inch on each side of the center line.

When the rises or the heights of the various lobes on the cams have been determined, the next problem is to determine their relative positions, or, in other words, the starting and finishing points of the lobes on the transferring and advancing cams, respectively.

Laying Out the Transferring and Advancing Cams

The location hole *B* in the cam shown in Fig. 3 is not used in the transferring and advancing cams, so that these cams, when made, can be shifted around to the desired position. However, it is best to start from some predetermined point when laying out the cams. After considerable experience in this class of work, the writer has found that less confusion will result if the point at which the piece breaks off is used

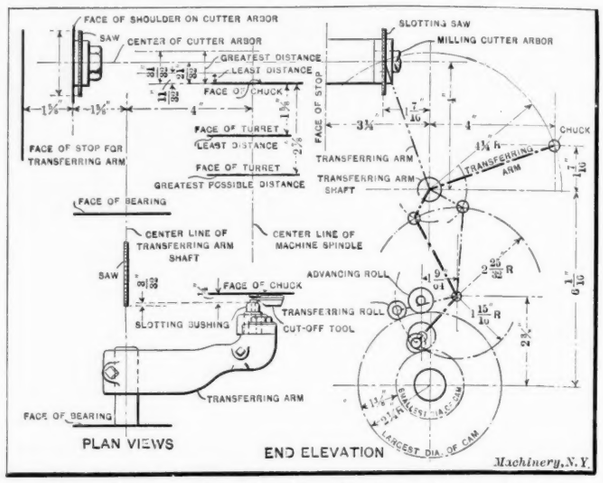


Fig. 4. Diagram used in determining the Rises on the Transferring and Advancing Cams

for the point at which the bushing should be located on the work. This, of course, cannot be determined exactly, but it is easy to locate it approximately.

The method of determining this is as follows: Taking the screw shown at *A*, Fig. 3, as an example, we will assume that the screw would break off when the teat was about 0.012 inch in diameter; then, assuming that thickness of cut-off tool blade equals 0.061 inch, length of bevel on cut-off tool or

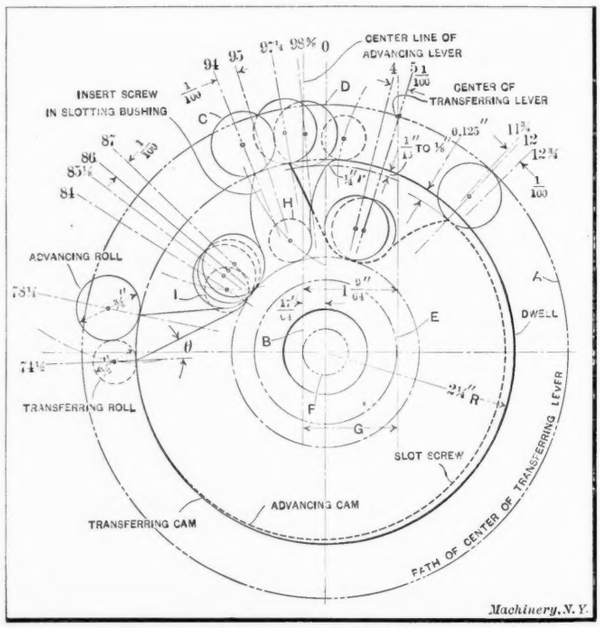


Fig. 5. Illustration showing Method of laying out Transferring and Advancing Cams

distance *C* (see Fig. 3) equals 0.020 inch, and amount to pass center equals 0.005 inch, we find that the distance the point of the cut-off tool will have to travel after the piece breaks off equals 0.025 + 0.006 = 0.031 inch. To find the hundredth line on the cam circle, divide the rise by the feed per revolution $= \frac{0.031}{0.00166} = 10.87$ revolutions $= 3$ hundredths.

* See "Designing Screw Machine Cams and Tools," MACHINERY, August, 1910.

Therefore we assume that the screw will break off when the center of the cross-side roll is at 95 hundredths. As this is where the screw will break off, it is necessary to have the bushing on the work previous to this; if we add 1/100, it will be sufficient.

Having determined the point where the slotting bushing should be located on the work we can proceed to lay out the transferring and advancing cams. The method of laying out these cams is shown in Fig. 5. As previously determined, the advancing cam is not cut down below the outer circumference except for the rise for feeding the screw to the saw and dropping back, so a circle is drawn with a 2¼-inch radius as shown, which represents the largest diameter of the cams. A circle *A*, representing the path of the center of the transferring lever, is next drawn. Then a vertical line *B*, representing the path of the center of the advancing cam, is drawn. When this line and circle have been drawn, we have the relative positions of the transferring and advancing rolls. The transferring roll is ½ inch in diameter, while the advancing roll is ¾ inch, on the No. 00 machine only.

To find the starting and finishing points on the cams, proceed as follows: Draw a circle *C* representing the advancing roll on the hundredth line marked 94; then draw a quick-rise on the cam with a 1½-inch radius. As the screw will be severed from the bar at 97¼ hundredths, this is the finishing point of the lobe for placing the screw in the slotting bushing. Next construct the quick-drop on the cam and draw another circle *D*, 1/16 inch below the largest diameter of the cam, so that the arm will drop back from the chuck before it begins to rise.

Now, to determine the position of the transferring roll, draw two circles *E* and *F* of such diameters that the distance *G* equals the relative distance between the center of the transferring arm lever and the path of the center of the advancing lever; these levers swing through arcs in planes at right angles to each other.

To obtain the center of the transferring lever, relative to the path of the advancing lever, draw a line through the center of the circle *D* and tangent to the circle *F*. Then draw another line tangent to the circle *E* and parallel to the line which is tangent to the circle *F* and passes through the center of the circle *D*. The point where the last drawn line cuts the circle *A* will be the center of the transferring lever. With this point as center and the compasses set to the radius of the transferring lever, strike an arc, and with its center on this arc draw the transferring roll circle *H*, touching the smallest diameter of the cam. The quick-rise on the transferring cam is then constructed, and the finishing point of this rise is made with a ¼-inch radius, so that the speed at which the arm is traveling will be decreased as it approaches the top of its travel. If this is not done, the arm will hit the stop and rebound, which will have a tendency to knock the screw out of the slotting bushing. When the transferring roll is on the highest point of the cam, the advancing roll should be at the bottom. A clearance of 1/100 is allowed between the point when the transferring roll is on the top of the cam, and the point when the advancing roll begins to advance the screw to the saw. The starting and finishing points of the lobes on the advancing cam for advancing the screw to the saw are constructed in a manner similar to that just described.

Nothing will be gained by dropping the arm down to pick up another screw before the teat has been reduced sufficiently so that the screw can be removed; hence as much of the cam surface as possible is used for slotting, thus preventing forcing the feed too much. To find the finishing point, we work backward, as it were, and locate the transferring roll at the base of the cam, as shown at *I*; then draw the quick-rise at an angle θ, which should be from 15 to 20 degrees for the No. 00 automatic screw machine. When this angle is drawn, we then have the finishing point on the transferring cam. The finishing point of the advancing cam is found by laying out the rolls in their respective positions, in the same manner as before, care being taken to retain the correct relations between the center of the transferring lever and the path of the advancing lever. This problem may seem to be rather complicated at first, but after some practice it will be found to be simple enough. A rise of 0.125 inch is generally allowed on the advancing cam, so that all sizes of screws within the range of the machine can be slotted with this same set of cams.

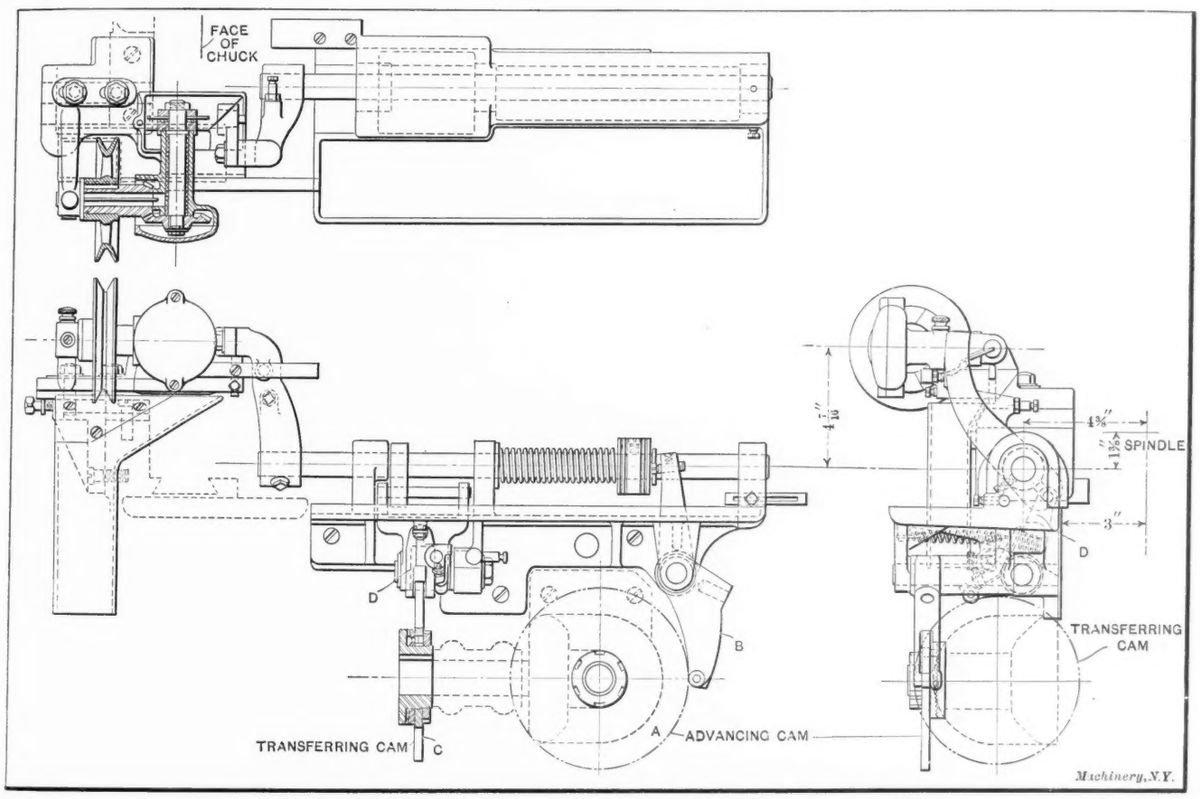


Fig. 6. Screw-slotting Attachment for the No. 0 Brown & Sharpe Automatic Screw Machine

Screw-slotting Attachment for the No. 0 and No. 2 Machines

The principle on which the screw-slotting attachment for the No. 0 and No. 2 machines works does not vary from that used on the No. 00 machine, but the advancing and trans-

ferring cams are located differently. On the No. 00 machine, these cams are held side by side on the front cam-shaft, while in the No. 0 and No. 2 machines, the advancing cam is held on the stud which holds the lead cam, while the transferring cam is held on the front cam-shaft. The movement of the levers, of course, in this case differs from that on the No. 00 machine. Referring to the illustration Fig. 6, which shows the attachment used on the No. 0 machine, *A* is the advancing cam and *B* the advancing cam lever; *C* is the transferring cam, and *D* the transferring lever. The method of carrying the screw to the saw is similar to that on the No. 00 machine, as are also the other movements, so that this will not need further description. It is, however, necessary to describe the method of laying out the transferring and advancing cams.

The method of laying out the transferring and advancing cams is illustrated diagrammatically in Fig. 7 where the advancing and transferring levers, as well as the cams, are shown in the same plane. The method of finding the starting and finishing points of the lobes on the transferring and advancing cams is the same as that used for the ordinary cross-slide and lead cams. The only point to remember is to retain the proper distances between the centers of the levers, and to swing them into their proper positions. A templet could be made for these cams, which would simplify the problem of laying out the starting and finishing points. A templet of this type was illustrated and described in the November, 1910, number of MACHINERY. However, when a templet is not available, the method previously described for the No. 00 machine

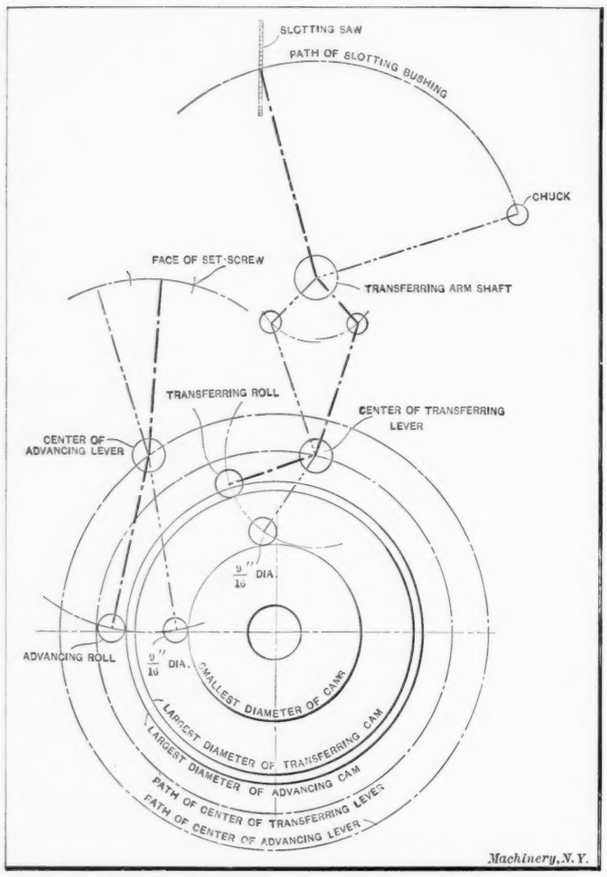


Fig. 7. Diagram used in laying out Transferring and Advancing Cams for the No. 0 Brown & Sharpe Automatic Screw Machine

can be used; that is, keeping the center distances in the same relation, in their respective paths, and swinging the rolls into the desired position.

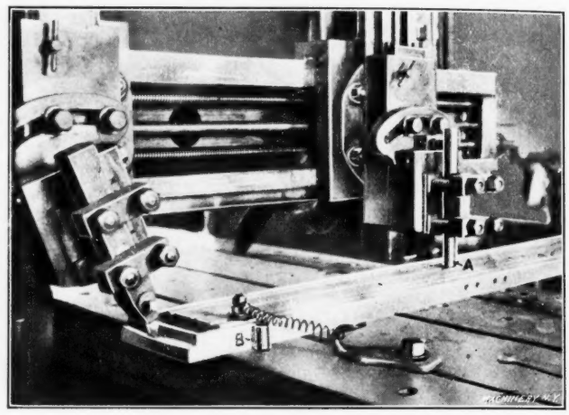
The screw-slotting attachment for the No. 2 Brown & Sharpe automatic screw machine does not differ from that for the No. 0 machine. The transferring cams in both these machines are made in two pieces, as it would be impossible otherwise to assemble them on the front cam-shaft. As there are no intermediate points at which the transferring arm is to dwell between the chuck and slotting saw, there are no calculations necessary for determining different heights on the transferring cam, the rise from the lowest to the highest point of the cam being sufficient to lift the screw from the chuck to the slotting saw.

The diagram shown in Fig. 4 should be laid out so that all the dimensions required for laying out the height of lobes on the cams can be found. It is always advisable to allow at least one-hundredth of the cam surface for clearance, between the starting or finishing points of the lobes on the transferring or advancing cams. This allows the transferring arm to become steady before the direction of its motion is changed.

* * *

METHOD FOR PLANING A CIRCULAR ARC

The accompanying illustration shows a method used in the shop of the Thompson Grinder Co., Springfield, Ohio, for planing a surface, having the shape of a circular arc, on the end of the tables of the grinding machines manufactured by the company. The method by means of which this is accom-



A Simple Method for Planing a Circular Arc

plished is simple and is clearly shown in the illustration. A plug *A* held in one of the tool-holders on the cross-rail enters a hole in the center of the grinding machine table and acts as a pivot about which the table can swing when actuated by the motion of the platen. The swinging motion is given to the grinding machine table by means of a stud *B*, inserted into the platen, which forces the grinding machine table to move past the planer tool each time the platen moves forward. A spring attached to a stud in one of the T-slots in the grinding machine table holds it against the stud on the return stroke. The simplicity and effectiveness of this method will undoubtedly appeal to mechanics.

* * *

The successful termination of the "ocean to ocean" journey of the "Pioneer Freighter" built by the Saurer Motor Co., New York, marks one of the important steps in the advance of the practical application of the motor car to commercial purposes. The truck carried a load of 3½ tons, its capacity being 5 tons. One of the interesting features in connection with this trip was that the truck arrived in New York from the Pacific coast with the original set of tires, and considering the kind of roads the truck had encountered, this must be admitted to be a remarkable performance. In many places the truck was run for a mile or more on the ties of the railway track, in the absence of better roads. Part of the way it was run across prairies where no road existed.

* * *

Among the most refractory metals known we have platinum, with a melting point of 1775 degrees C. (3227 degrees F.), yet platinum alloys with tin and lead at a temperature of the melting points of these two metals. Many a young chemist has undergone the sorrowful experience of accidentally getting a small amount of these metals into his beautiful new platinum crucible, and seeing a hole form in the crucible when it was heated. The fact is simply that the high melting point of the platinum does not protect the crucible from the dissolving action of the metals mentioned.—*Dr. Hans Goldschmidt in Reactions.*

MACHINE SHOP PRACTICE

THE MAKING OF REAMERS—3

By J. C. CUSTER*

A slender reamer should be supported in the middle when fluting, because nothing will ruin the edge of a cutter as quickly as work that springs or "gives" under the strain of the cut. Milling machines are generally provided with a support or jack for such purposes, but for supporting short work, such as taper pin reamers, a "home-made" block sometimes answers the purpose better. Such a block—an adjustable wedge—is shown in Fig. 10. Such a wedge can be easily and cheaply made if a corrugating mill is available for cutting the teeth, but if no such mill is at hand, the block shown in Fig. 11 is to be recommended.

The Adjustable Reamer

The adjustable reamer spoken of in the following, having blades inserted as indicated in Fig. 14, is sometimes called

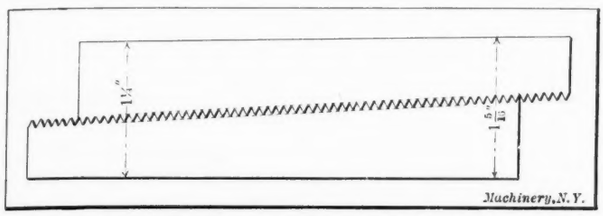


Fig. 10. Adjustable Wedge Block for Supporting Slender Reamers while Fluting

the Clough reamer, after the original maker, R. M. Clough, of Tolland, Conn. The seats for the blades are first roughed out. This is done with a narrow cutter or saw of about the same width as the seat for the blade at its narrowest point. In case the body is of tough material, rough out with a saw having its cutting face ground to an angle of 10 degrees with the axis. Set this saw central with relation to the work, and start the cut for the first blade; then index 10 degrees, and move the table crosswise so that the saw will enter the slot previously started. Now cut the slot to the desired depth, and proceed with the rest of the seats the same way. Then index back 20 degrees, and again move the table crosswise so that the saw will enter the slot, but use in this case a saw ground

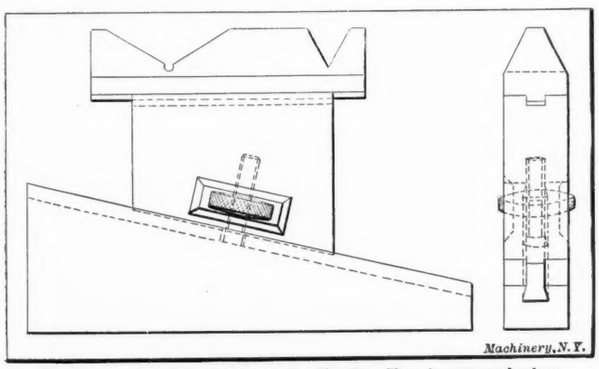


Fig. 11. Another Adjustable Block. The Top Shoe is removed when Supporting Wide Surfaces

to an angle of 10 degrees in the opposite direction. Now cut through the same slots once more in such a way that there is about 0.020 inch of stock left to be removed by the finishing cutter. To index 10 degrees when the worm-wheel has 40 teeth, move the index crank 1 3/27 of a turn.

It can readily be seen that the seats, if roughed out in this manner, will have an angle of 10 degrees on each side. We could finish the seats in the same way if the bottom of the seats ran parallel with the axis of the body, but since the bottom makes an angle of 2½ degrees with the axis for the purpose of adjustment, the bottom of the seats will be narrower at the shallow end. On account of this, the work is swung sideways ½ degree each way when roughing with a 10-degree saw. This swinging sideways is effected by shifting the tailstock or the dividing-head on the table and not by swinging the table or saddle. Swinging the table will only bind the saw in the slot, and will not have the effect we are trying to obtain. An auxiliary platen is, however, the best that can be used when angular work of this kind is milled.

After the roughing cut is finished, put on the vertical milling fixture and finish with a dove-tail cutter. The cutter should be run at a fairly high speed for this finishing operation, as a cutter of this kind is more liable to break under slow than under high speed. The feed, however, should be fine.

In case this work is done without a vertical milling attachment, the method used must be somewhat different. An auxiliary platen or table, such as is used when milling bevel gears, is employed. On this platen the dividing-head and tailstock are placed in the usual way. Then set the auxiliary table to an angle of 2½ degrees and bring the center of the work to the center of the spindle holding the dove-tail cutter. Use a high-speed milling attachment for this work, as the speed of the spindle is too slow, especially if the machine is geared down to suitable speeds for tool steel. If an auxiliary table is not available, take the tongue out of the dividing-head and set it sideways 2½ degrees and strap it down to the table. A still better way, however, is to hold the work in a vise set at an angle of 2½ degrees.

If no high-speed attachment is available then the situation is somewhat difficult, as the spindle runs too slow and the feed is too coarse for this work. In such a case, however, provide a few extra cutters before starting, guard against "backcut", and feed by hand slowly and steadily. Not infrequently adjustable reamers are made very long for jig work. These reamers, as a rule, cannot be milled in the dividing head,

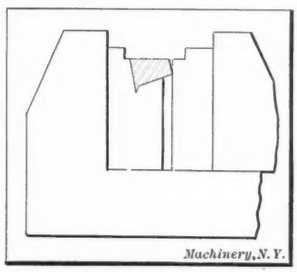


Fig 12. Reamer Blade held between Blocks on the Vise

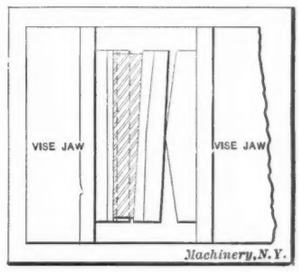


Fig. 13. Old Reamer Blade held between Blocks for Re-milling

because of their length, but must be held in a vise; the process of milling is otherwise the same as described.

It is common practice to make these reamers in such a manner that the blades project at the end of a new reamer. This is a decidedly bad feature, for even a careful operator will sometimes get too close to the bottom of a hole and break off the unsupported ends. Wherever possible, the taper for the adjustment should be reversed, so that the shallow end of the blade is in front, in which case a new reamer has the ends of the blades flush with the body, while the back-ends of the blades are left longer for adjustment. A reamer made in this way is adjusted for a larger diameter by driving the blades forward, and the ends are kept flush with the body by grinding at the end. Small reamers, however, should not be made in this way, as it would weaken the shank just back of the body too much. Besides, the shallow end of the seat in a small reamer would not give adequate support to the cutting end of the blade.

The blades for dove-tailed reamers may be planed or milled. If we are making or re-blading reamers of this kind on a small scale only, then milling is to be preferred. The stock for reamer blades, if not rolled into dove-tail shape, should be rectangular and no larger than necessary. It is cut in single lengths, the blades being from 3/16 to 7/16 inch longer than the body. Now one side—the bottom of the blade—is finished, and then an 80-degree cutter is used to mill the sides of the blades. Blocks, as shown in Fig. 12, may also be used in connection with an ordinary straight milling cutter of the right width. If it only rarely happens that new blades have to be made, then, of course, it does not pay to make these blocks, especially since a block will fit only one thickness of blade properly.

* Address: 819 Broad St., Bridgeport, Conn.

The old blades of reamers may be annealed, cut shorter (from the small end) to fit a smaller reamer, and then used over again; in Fig. 13, a method is shown for holding old blades for re-milling.

After a reamer is bladed, it is returned to the lathe, the ends are faced off and turned to about 1/64 inch over size. Then the faces of the blades are milled radial with a 90-degree cutter, at the same time cutting into the body of the reamer to a depth of about 1/32 inch. This gives additional room for chips. Finally, reduce the land to the proper width, without cutting into the body, as the blades should have all the backing possible. (See Fig. 14.)

Center Reamers

The small center reamer is held in the chuck and the end supported with a jack-block; for four teeth use a 95-degree cutter, run it in a right-hand direction and sink it into the work by raising the table. The center reamer with a teat is held in the same way, but the end is supported by the center. In this case we may run the machine in the usual way, *i. e.*, left-hand.

The "bull" center reamer can be cut on centers if the teeth are not too long; otherwise cut it with the head raised to an angle of about 22 degrees. This angle depends on the number of teeth cut, and the form of the cutter used. The cut should be started at the back end of the flutes and proceed towards the front; if much of this work is to be done, use an arbor with a right-hand screw and nut.

Grinding

After the hardening process, which does not differ from that used for any other tool of a similar nature, and after the centers have been cleaned from scale and grit, ascertain first how much the reamer has warped in hardening; this is done by holding it between the centers of a lathe and spinning it around by hand. A novice at this should use an indicator rather than trust his untrained eye. It will be remembered that the solid reamer previously referred to was turned 1/64 inch larger than the required size. If it be found that it will not finish up in the grinding, because of the warping,

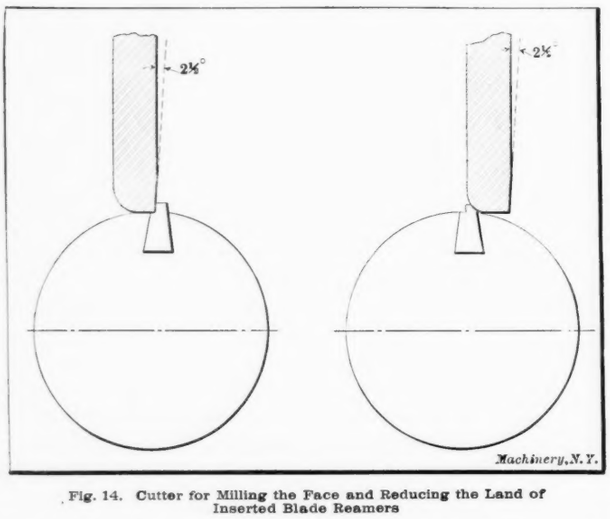


Fig. 14. Cutter for Milling the Face and Reducing the Land of Inserted Blade Reamers

then it must be straightened previous to being ground. Certain types of reamers as well as certain steels warp more in the hardening than others. Some reamers ought to run very nearly true before being ground, as for instance a taper pin reamer, 5/32 inch at the small end and 3 1/4 inches long. If this reamer is 1/64 inch over size and runs out 0.014 inch, and is then ground, it will "clean up", but the result will be that the teeth will be ground down close to the roots and leave no room for chips on one side, while the opposite teeth are correspondingly weak.

A suitable grinder for the work considered is the regular plain grinder, which will grind taper as well as straight work. Assume that we start by grinding the taper shank on the one-inch reamer. This is done to the gage used when turning the blank, but if such a gage is not available, an adjustable taper gage can be used. A reliable gage of the adjustable type is shown in Fig. 15. This gage is set to a No. 3 Morse taper, using preferably a plug gage for that purpose. The shank is then ground to fit the gage. Now proceed to grind the straight part of the shank which was turned approximately to the required size, and, therefore, only is ground for finish. The shank must, of course, be smaller than the reamer. Next in order grind the reamer proper, which should be left about 0.004 inch over size. The order in which the various parts are ground may be reversed. If, for instance, the grinder is set for straight work, and we know that it will grind absolutely straight at that setting, then we take advantage of this by grinding the straight parts of the reamer first. The reamer is now ready to be backed off, an operation which is done in

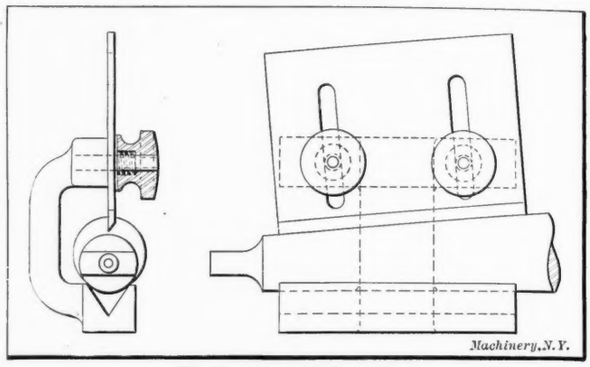


Fig. 15. Adjustable Taper Gage

another machine. Before taking up this matter, however, we will consider the plain grinding of some of the other types.

The taper reamer is generally ground to a gage, but in the absence of a gage, we must rely on the graduations on the grinding machine. These generally indicate the taper per foot, and reamers ground by setting the table to these graduations are satisfactory for a large class of work. If the taper of a reamer is expressed in degrees, and is to be ground without a gage, ascertain first how the angle is to be understood, *i. e.*, whether it is to be measured from the center line or if it is the "included" angle. Then convert the degrees into "inch taper per foot", and set the grinder according to the figures thus obtained. Sometimes grinders are graduated to give degrees as well as taper per foot.

End cutting reamers are used for various purposes, for example, for straightening holes, particularly deep ones. If the hole is to have a good finish the reamer should be ground from 0.002 to 0.004 inch under size so that a finishing reamer may be used afterwards, because an end cutting reamer generally leaves the hole somewhat rough. If the finish of the hole is not important, then grind this type of reamer to size. A reamer for straightening holes should have a slight taper backwards, say 0.002 inch per foot, and the flutes ought to be longer than in the chucking reamer to insure a straight course of the reamer. An end cutting reamer is also used in automatic machines when it is desired to have a hole reamed clear to the bottom. The feed in an automatic machine is much finer than when feeding by hand in other machines, and for this reason the reamer is apt to cut "full". The experience of the writer is that good results are obtained by grinding such a reamer about 0.001 inch under size at the end, and with a back taper of about 0.005 or 0.006 inch to the foot. Since this reamer is not used to straighten the hole, the flutes are shorter than in any other type for ordinary work. As the teeth of an end cutting reamer are not backed off, we do not grind it 0.004 of an inch over size as in the case of the one-inch machine reamer, but grind it to size in the plain grinder. Sometimes it is well to remember the fact that a hole, reamed while heated, will contract when cooling off. Other types of reamers need not be considered in detail, as the operation of grinding is more or less the same as already described.

Next in order is the backing off or relieving, which can be done in various ways. A good method is to use a so-called cutter and reamer grinder. Another method is to use an electric grinder held in the tool-post of a lathe while the reamer

is held between the centers. The most economical and best results, however, are obtained with a grinder specially built for the sharpening and backing off of reamers. Such a grinder is made by the Bullard Machine Tool Co., Bridgeport, Conn.

The sharpening or backing off of reamers in a lathe is a poor makeshift, and should never be resorted to unless no other means are at hand. Sometimes it happens that a large reamer must be sharpened that is either too long or too large in diameter for the capacity of a grinder. In such a case the electric grinder, used in a lathe, will answer the purpose.

Now assume the one-inch reamer being made is to be backed off in a cutter and reamer grinder, say of the Brown & Sharpe Mfg. Co.'s make. This backing off is an important operation. The amount of clearance that a reamer tooth should have is a point on which "the learned are not agreed" as yet, and it, therefore, may be inferred that a little more or less will not affect the cutting qualities of the reamer to any great extent. Too great a clearance angle is apt to cause the reamer to chatter, particularly when working in brass or bronze. A newly ground reamer has a greater tendency to chatter than one that has been used for some time. If there be too little clearance, the reamer will not cut freely, as the lands will rub against the walls of the hole. In many cases the outcome will be a rough hole, or the reamer may "get stuck", and something will break if there is sufficient power behind it. A point well worth remembering is this: A suitable clearance for reamer teeth, expressed in degrees (the face of the tooth being radial) is not a fixed amount, but varies for different diameters—the smaller the reamer the greater should be the angle of clearance. Note also that if the cutter and reamer grinder is set about right to produce a suitable clearance on a large reamer, a small reamer would not get suitable clearance at that setting.

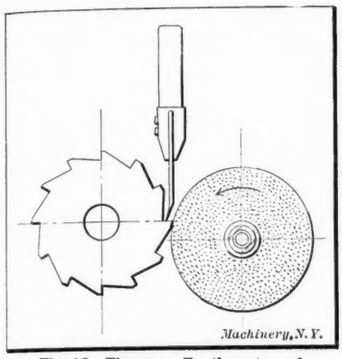


Fig. 16. Finger or Tooth-rest used from the Top

A simple method to regulate the clearance on a straight reamer is by raising or lowering the finger or rest that the tooth slides on in pasing in front of the wheel. The clearance of the taper reamer, however, must not be regulated that way. When sharpening or backing off a taper reamer, the rest should stand in the plane of the axis of the reamer, and the desired clearance should be obtained by raising or lowering the reamer, relative to the wheel center. This can be done by the bar carrying the centers as well as by means of the adjustment provided in the swivel-head. The tooth-rest can be secured in the swivel-head, and if so secured, the tooth does not slide on the rest, but the rest moves with the work. This method, while it is an excellent one for grinding certain tools, cannot be recommended for reamers because of the possible irregularity on the face of the teeth, due to the warping in hardening. The tooth that is being ground should always slide on the rest, because of the irregularities otherwise introduced, due to the uneven spacing of the reamer teeth.

If a tooth is ground against the face it has a keener and smoother edge than when ground in the opposite direction. In spite of this good feature, the beginner should never attempt to grind a reamer that way, since there are several disadvantages connected with this method, which more than outweigh the advantages gained. The principal disadvantage is that the rest has to be used from the top (see Fig. 16), and if so used, it gives no support to the tooth; the tooth is held in contact with the rest by hand, while the tendency of the wheel is to draw it away from the rest. If this happens, it usually means damage to the reamer, the wheel or the operator, and the chances are that all three get "banged up".

If the lands of reamer teeth were of uniform width we could support the tooth from below, *i. e.*, we could let the back of the tooth slide on the rest instead of the face and then grind against the face, but an uneven spacing produces a difference in the width of the lands on straight reamers, while taper reamers have a tapering land whatever the spacing.

The wheel used for backing off or sharpening reamers should be of fair size. Small wheels produce a cut of too great a curvature. The wheel should be of medium grade, as soft wheels produce a rough cut, and the hard ones become easily glazed, which is apt to draw the temper. The swivel-head is graduated to degrees, but for work required to be absolutely true, such as reamers, we cannot rely on these graduations exclusively. The swivel-head is to be set to the 90-degree graduation when backing off the straight part of a tooth on a straight reamer, but since the swivel-head is only about four inches in diameter, the graduation, reading to degrees, is rather crowded, and therefore errors in this setting are easily made. The reader no doubt knows how seldom it happens that work comes straight in the lathe without resorting to the cut-and-try method when setting the tailstock, and in the case of our one-inch machine reamer, which is 12 inches in length, the chances for error are about six times as great in the cutter and reamer grinder as they are in the lathe, when turning the same reamer; *i. e.*, if there is an error of 0.001 inch in the setting of the tailstock of the lathe, it will result in an error of 0.002 inch in the entire length of the work. But an error of 0.001 inch in the setting of the swivel-head in the grinder will produce an error of 0.002 inch in each two inches of length of the work—two inches being the radius of the swivel-head. As the reamer is 12 inches long, the ratio of error between grinder and lathe in this case is as 6 to 1; the longer the work, the greater this ratio.

The rest should be made of tool steel and hardened, and the corners rounded to insure smooth action. It should be a trifle wider than the wheel. When backing off spiral reamers, the rest is set over to correspond with the angle of the spiral. A better way, however, is to make a special rest for spiral work, and grind this rest to the angle of the spiral.

After the reamer is backed off and brought down to size (measurements are generally taken with micrometers), grind a lead or taper at the end. This lead may be of various lengths to suit various conditions. It must be very short or entirely absent if the reamer is intended to ream down to the bottom of a hole, but if the hole runs through a piece of work then good results ought to be obtained with a lead of about ½ inch in length. The taper should be about 0.005 or 0.006 inch. The back end of the reamer is also slightly tapered to prevent the ends of the teeth from scratching when passing through the hole. Finally, the chamfered corners are backed off, which finishes the reamer. The corners may be rounded instead of chamfered, but chamfered corners are easier to grind even, as the grinding can be done on centers.

Sometimes a new reamer will ream a hole "full" at first. To overcome this, when standard holes are wanted from the beginning, we stone by hand after the reamer has proved to cut large. Stoning a spiral reamer should be done at the end only, for a stone cannot be brought in proper contact with a helical tooth.

The foregoing is, in the main, the writer's way of making reamers. If other methods "just as good" or better are employed elsewhere the writer hopes that they will be made public. If he has not made himself clear enough on some points, he asks to be excused on the grounds that he has but little time for writing, as he is too busy—making reamers.

* * *

An old building completed in 1852 was recently demolished in Hamburg, Germany. The iron anchor bolts used were completely encased in concrete and were found as fresh and bright as would be new iron, with no traces whatsoever of rust. This indicates that iron will be perfectly preserved in concrete for an unlimited time if properly encased.

* * *

In designing machine parts, avoid blind threaded holes wherever possible. A hole running clear through the piece is much easier to tap, and if many holes are required to be tapped, the saving is quite considerable.

MOUNTING BLUEPRINTS

By D. U. B.

Many good suggestions for mounting blueprints have been offered in the columns of MACHINERY, and here is still another.

Our company discarded cardboard-mounted prints in preference to tin long ago, but our method of mounting is somewhat different from that mentioned by J. B. & Co., in a recent issue. Our tins are made of No. 28 galvanized iron sheets, which is probably as thin as can be used without warping, especially as the treatment received at the hands of some shop men is rather rough. However, lighter material might be used in some cases and this would reduce the cost somewhat. The tins are made ⅝ inch larger all around than the print size, including a ¼ inch lap, which not only stiffens the tins, but also makes the edges somewhat easier on the hands.

We make a paste of flour and water about as thick as that used by paper hangers, and cook it in the patternmaker's electric glue heater. The back of the print is thoroughly covered with paste, but this must be applied quickly so as not to let the print get more wet than necessary; if not done quickly enough, a chemical action takes place between the water in the paste and the galvanized iron, resulting in spots on the prints. The print is then smoothed down well on the tin with the hands or with a rubber roller, taking care to get most of the wrinkles out, and incidentally working all the surplus paste out from under the print, after which it is thoroughly dried. In summer, we dry our prints in the sun; in winter we put them near the radiator, and have never experienced any trouble, unless it was while breaking in a new "blueprint boy".

After drying, the varnish is applied; we use common yellow shellac varnish, which answers our purpose very well, but the white shellac varnish is preferable. To make corrections, we scrape the varnish off with a knife where the change is to be made, and make the correction with ink. After the ink is dry, the print is varnished again.

To remove the prints from the tins let them soak in water an hour or so, when they can be taken off with the utmost ease, and are ready to be used again. For cleaning, the mounted prints can be washed in benzine or soapy water—something you could not do with those mounted on cardboard, even if they lasted long enough to need cleaning. If you wish to use an old tin which has been previously mounted with shellac, burn all the varnish off before applying the paste; otherwise, the print will not stick, and it is likely to become spotted.

We have about 1400 mounted prints in the factory, some of which have been in use for fifteen years, and we find this method better than any other.

* * *

TAPS AND TAPPING

By "A"

While the writer always welcomes criticisms from persons who are familiar with, and thorough in their investigations of, the subject under consideration—without such criticisms and resulting discussion, progress would be slow—he cannot see any use for such criticism as made by Mr. Bliden in the August number of MACHINERY in which this writer referred to an article entitled "Taps and Tapping," which was published in the June number. Mr. Bliden's knowledge of tap making in general seems to be very limited, because he states that the writer "advances a new theory" in tap making. The theory is not new, as many kinds of taps, for example, master taps (also called long taper die taps), machine nut taps, and stay-bolt taps, are regularly made as outlined in the article in the June issue by practically all the prominent tap manufacturers, and have been so made for years—by some, of which the writer has positive knowledge, for as long as twelve years. The machine nut taps and stay-bolt taps have been made in this manner on account of the heavy duty to which they are subjected, and the master taps owing to the finish required in the tapped hole. This indicates that the tap makers are aware of the superiority of taps made as outlined by the writer, over those ordinarily made for regular shop use, and the writer is sure that were it not for the added cost in the making of taps in this manner, all taps (even the first tap in a set of hand taps) would be so made, whenever heavy duty or good finish were required. It was not in order to promulgate a new theory that the article in the June number was written, but it was the absence of definite formulas of *how much* to taper the taps that led the writer to make experiments along this line and give to the readers of MACHINERY the benefit of these experiments by compiling the tables accompanying the article.

The critical reader who carefully reads the article referred to will find that the writer did not deal with tap making in its entirety, but that he only suggested "further means and methods for making not only square-threaded taps, but taps with any form of thread whereby the ultimate object—a straight-threaded hole and a smooth and correctly formed thread—may be obtained." The writer did not state that the defects with which he dealt in the article criticized were the most serious in taps as generally made, as Mr. Bliden seems to have interpreted it in his criticism; one particular phase of the subject only was dealt with.

Mr. Bliden also remarks that nothing was said about the relieving of the tapered thread, and seems to think that they were not to be relieved. The writer did not think that it was necessary to call the attention of the readers of MACHINERY to this matter, especially as the subject of relief was not dealt with. The critic might just as well have drawn the conclusion that the taps as described were not fluted, as nothing was said about fluting; because the relieving of the thread in a taper-threaded tap may be considered fully as important a feature as the fluting. The relief of taps has been treated so thoroughly in MACHINERY in the past that it would seem unnecessary to repeat any of the matter previously published. (See MACHINERY, "Relief of Taps," October, 1905; "Machine Taps," February, 1907; "Hobs and Die Taps," March, 1907; "Taper Taps," March and April, 1908; "Special and Adjustable Taps," July, 1908.)

Mr. Bliden's criticism regarding the square-threaded taps indicates superficial reading of the article criticized, because the second and third taps in the set of taps shown are provided with threaded pilots so that the taps will "lead" with the preceding taps, which he thinks they would not do.

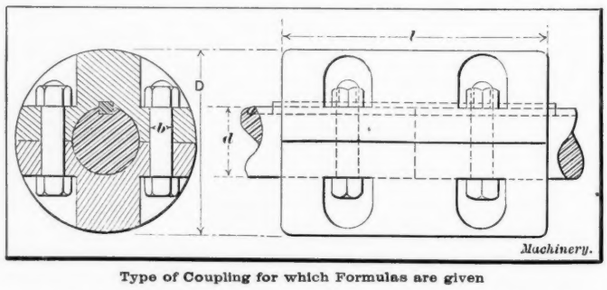
It does not seem to the writer that discussions of this kind add anything to the information given in the pages of MACHINERY, but he considered it necessary to reply. However, he wishes to state that the controversy on his part is closed.

* * *

FORMULAS FOR CLAMP COUPLINGS

By D. TAPPAN

In the How and Why columns of the August number of MACHINERY is a request for a formula for determining the number and diameter of bolts for clamp couplings. The writer



Type of Coupling for which Formulas are given

submits herewith formulas for complete couplings which have given satisfaction in general practice. Let d = diameter of shaft; then:

D = diameter of coupling = $2\frac{1}{2}\ d + \frac{1}{2}$ inch.

l = length of coupling = $4\ D$.

b = diameter of bolt = $1/3\ d + \frac{1}{8}$ inch.

For couplings with less than 3 inches diameter of shaft use four bolts, and for larger shafts use six bolts.

These couplings are usually clamped together and bored to size with a piece of rather heavy paper between the two halves. After boring, this paper is removed, thus giving the necessary space between the halves for clamping tightly.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

DIE FOR PIERCING CAST IRON

The writer has lately had the novel experience of designing dies for the punching of gray-iron castings in power presses. He does not know what experience others have had in working this metal in a similar way, but never having heard or read any articles on this subject, presumes that a short description of the methods and devices used will be of some interest to the readers of MACHINERY. Having a great many thousand gray-iron castings of the form shown in Fig. 2 to drill, and also having had a great deal of trouble and inconvenience in getting the keyhole *A* cast clean and accurately, it was decided to try piercing the holes *A*, *B*, *C* and *D*. Before laying out the plan of the dies, some of the castings were experimented upon with a simple round punch and die to ascertain the effect of the sudden blow on the comparatively brittle material.

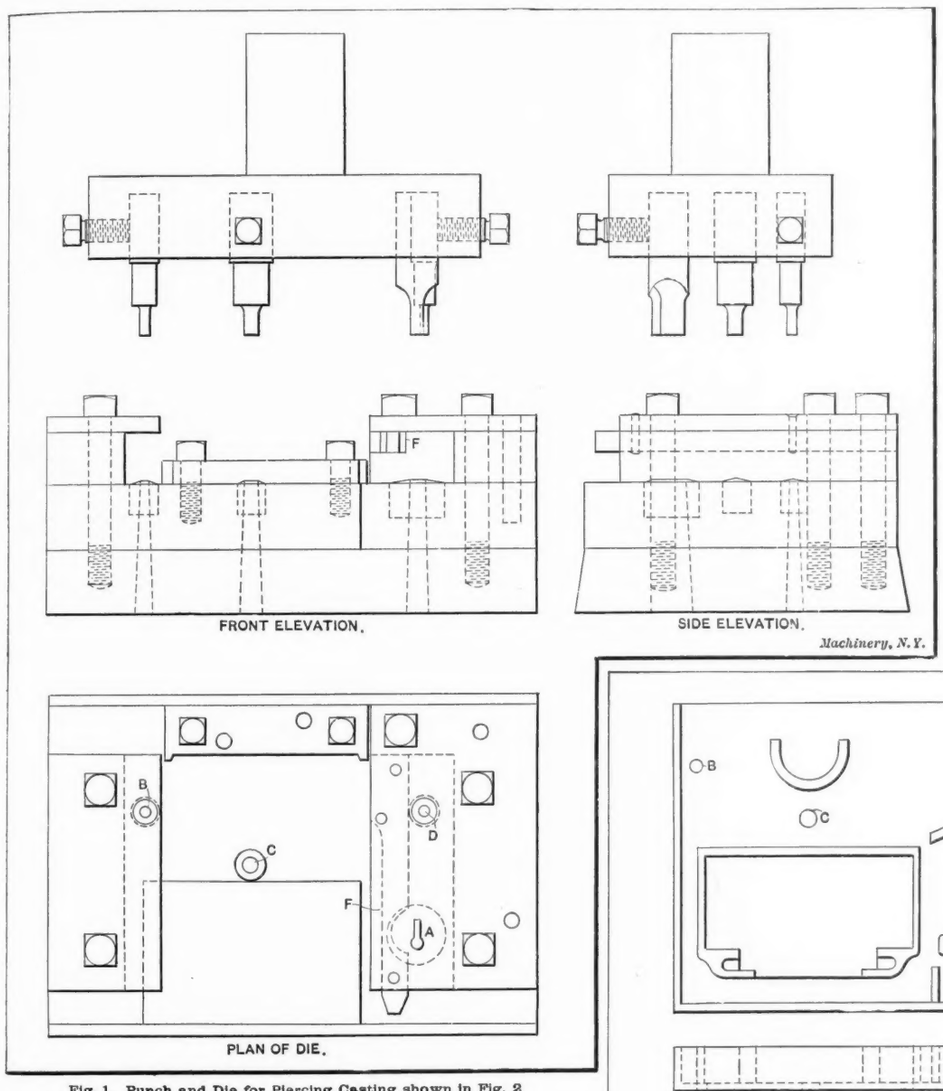


Fig. 1. Punch and Die for Piercing Casting shown in Fig. 2

In this test it was found that it is not practical to approach the edge of the casting very closely, about one-half inch being the nearest that is safe without cracking the casting, unless there is a rib or flange to resist the strain imposed on the iron. The castings used were of a good quality of soft gray iron, made by a foundry well known for its excellent quality of work, and were free from sand and objectionable scale. The first operation was to mill them at *E*, Fig. 2, from which groove the castings were located on the die Fig. 1, by the hardened steel gage shown at *F*.

The faces of all the dies, which are inserted in a machine-steel die-block, are crowned and the crown is brought almost to the edge of the hole (approximately 1/64 inch) to overcome any tendency to spring or strain the casting. The construction of the simple die as shown in Fig. 1 is obvious, and does not need explanation or comment. There are doubtless many other similar manufactured articles on which this process could be used to advantage, if the stock is sufficiently thin and the holes so placed as to make the operation successful.

Previous to making the die shown, when having a similar piece to machine, we would construct a jig for holding the work, and if the quantity of the articles to be made warranted the expense, a multiple-spindle drilling head would also be laid out and made, which, of course, was somewhat expensive, and in the specific case in hand would not help out on the keyhole or other irregular shapes. The die has resulted in better work and has greatly reduced the cost of the work, as well as the cost of tools. It would be of interest to the writer to hear in MACHINERY of processes similar to this, as there is "more than one way to skin a cat," and new methods and kinks appeal to all of us.

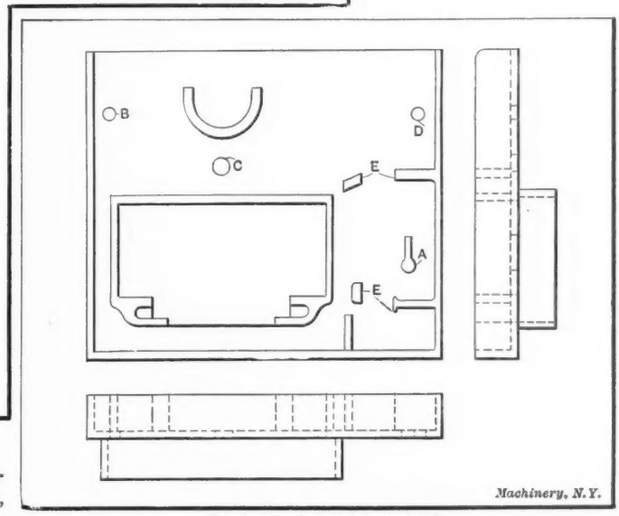


Fig. 2. Casting to be punched

Aurora, Ill. CORWIN LAMOREAUX

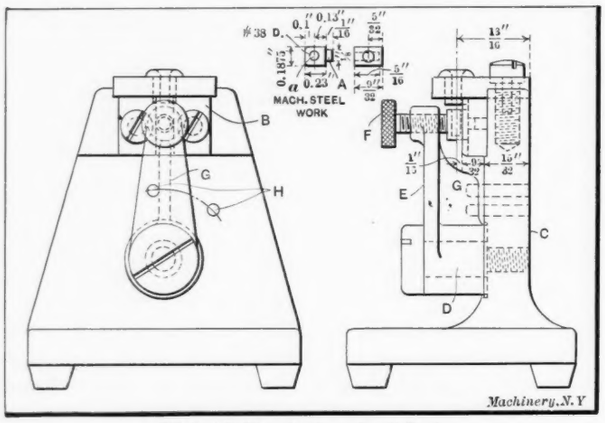
PREVENTING PENCIL POINTS FROM BREAKING

The writer suggests a very simple method for preventing the pencil point from breaking if the pencil falls to the floor. This method answers two purposes, that of making one end of the pencil heavier, and also of preventing it from falling

out of the pocket. The method consists in simply twisting a rubber band around the pencil near the top. This method is not as elaborate as those suggested by Mr. W. Thompson and "Designer" in recent issues of MACHINERY, but it fills the requirements, and it overcomes the objections to the methods proposed by them. RUBBER

DRILLING JIG FOR A SMALL POST

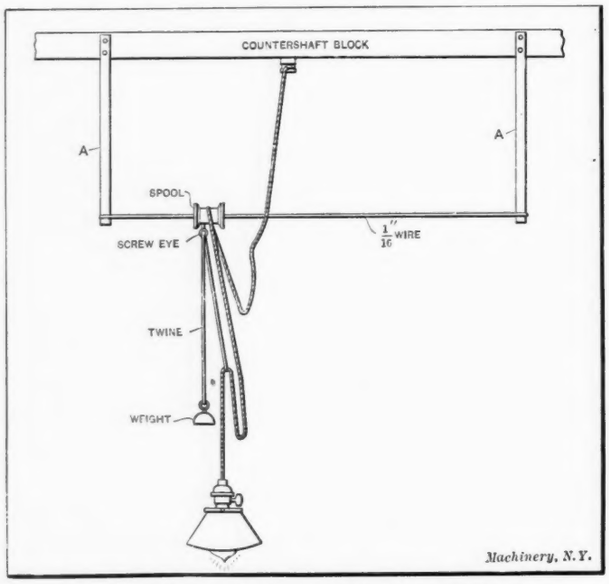
The accompanying illustration shows a simple and efficient jig for drilling the hole *a* in the piece shown, which is a small screw machine part, cut off and formed in a previous operation. The work is located by the teat *A* in a hole in the locating plate *B*, which is made from tool steel and hardened. The locating plate *B* is fastened to the casting *C* by flat-head screws. The casting *C* is tapped to receive the stud *D* on which the swinging or clamping arm *E* works. An adjusting screw *F* is held in the swinging arm *E*, and is used for clamping the work in the jig. The rib *G* on the arm *E* engages with pins *H* which prevent unnecessary movement, only allowing the arm to swing through a small arc sufficient to clear the work. Only a quarter turn of the knurled screw *F* is required to clamp or release the work. DAYTON



Efficient Drilling Jig for a Small Stud

ADJUSTABLE ELECTRIC LAMP FOR THE LATHE

It is convenient to have an electric lamp which can be easily adjusted to any position along the entire length of the lathe bed, and to any height. A lamp of this type is in use in the Aurora Tool Works, Aurora, Ind.



A Convenient Method of Holding and Adjusting an Electric Lamp

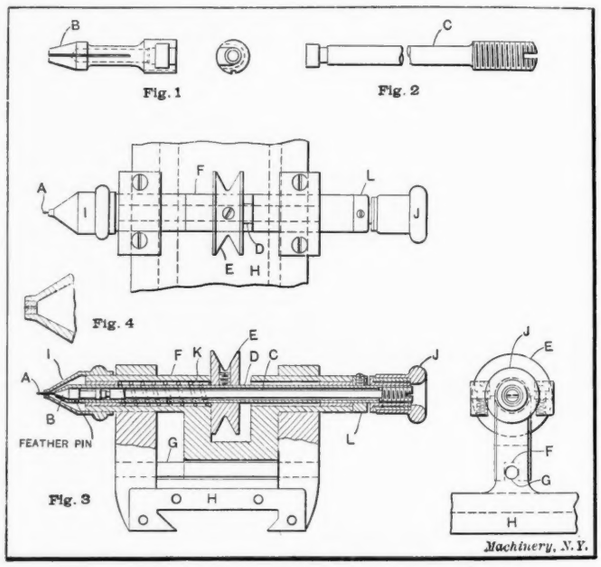
The device for holding the lamp, as shown in the accompanying illustration, is very cheaply made, by taking two wooden strips *A* and fastening them to the block which holds the countershaft. A piece of wire about 1/16-inch diameter is stretched from one strip to the other, and is drawn fairly tight; a small spool is placed on this wire, and can be slid along the wire to any desired position between the strips.

The electric light wire is fastened to the spool, leaving enough slack wire so that the spool can be moved to any position. A small screw-eye is screwed into the spool which serves as a pulley for holding the twine used in adjusting the lamp to any height. One end of this twine is tied to the electric light wire, leaving enough slack wire so that the lamp can be lowered or raised. On the other end of the twine is fastened a small weight to balance the weight of the lamp.

Aurora, Ind. ALVIN C. RENNER

A FIXTURE FOR DRILLING SMALL HOLES

The accompanying illustration shows a small fixture designed for drilling very small holes. The drill *A* is held in the chuck *B*, an enlarged view of which is shown in Fig. 1. The chuck is tightened on the drill by screwing up the rod *C* (Fig 2), the end of which engages with the chuck, so that the latter may be opened or closed by screwing the rod *C* forward or backward. The outside spindle or sleeve *D* is rotated by means of the pulley *E*, and the drill chuck rotates in unison with it, as it is keyed with a feather pin as shown in Fig. 3.



Figs. 1 to 3. An Efficient Fixture for Drilling Small Holes

The spindle *D* is supported by a bushing held in the yoke *F*, which slides forward and backward, the rod *G* preventing it from turning. The yoke *F* is held in the casting *H* which forms a part of the fixture.

In order to support the drill point as it enters the work, a thimble *I* is fitted to the front end of the yoke *F*. This thimble carries a small bushing through which the drill works, as is clearly shown in the enlarged view, Fig. 4. For convenience in operating, a revolving button *J* is placed at the end of the drill spindle. In operation, the spiral spring *K* presses the pulley *E* back until it strikes against the yoke *F*, and when in this position the drill point is withdrawn until its point is in the thimble bushing, thus protecting the drill and leaving it ready for action.

When the operator presses the yoke forward, the pressure of the spring *K* keeps the drill point back until the end of thimble *I* comes in contact with the piece to be drilled, after which the drill as it is supported by the bushing in the thimble, passes through the piece. After the hole is drilled the spring acts to keep the thimble in contact with the work until the point of the drill is protected again in the bushing; the yoke is then drawn back until the drill is clear of the work.

The distance that the drill may project from the bushing is

regulated by means of the collar *L*. In operation the pulley *E* would be set back a slight amount on the spindle *D*, so that the collar *L* would regulate the depth of the hole, and the pulley *E* would come against the face of the yoke on the return stroke, thus preventing the point of the drill from being drawn entirely through the bushing.

This fixture was designed for rapid duplicate drilling, and is adaptable to a number of different jobs requiring the drilling of holes of very small diameter. For convenience in assembling, the upright parts of the casting *H* are provided with caps, which are screwed onto them, thereby allowing the removal of the yoke and spindles without disassembling them.

F. B.

A COMBINATION SURFACE-GAGE AND TRAMMEL

A useful combination tool which has recently been brought out by the Mechanics Tool Co., of Preston, England, is shown in the accompanying illustrations. The base of the surface-gage, or scribing-block, is made of cast iron (see Fig. 1), into which is screwed a ⅜-inch square steel rod, 8½ inches long. On this rod is held a patented form of scriber-holder which may be rapidly moved up or down, and locked in the desired position. The two knurled screws *D*, Fig. 3, are used for fine adjustments. An extension rod, 14 inches long, may be screwed into the top of the 8½-inch rod, thus increasing the capacity for height. The principal application of the longer rod when used alone or when screwed to the shorter one, is as a trammel or caliper-gage. By using two of the scriber-holders, a trammel-rod is evolved, as shown in Fig. 2, and by turning the two bent ends of the scribers so that they face each other, a calipering tool is produced. For internal work or for measuring between inside faces, the bent points of the scriber are reversed.

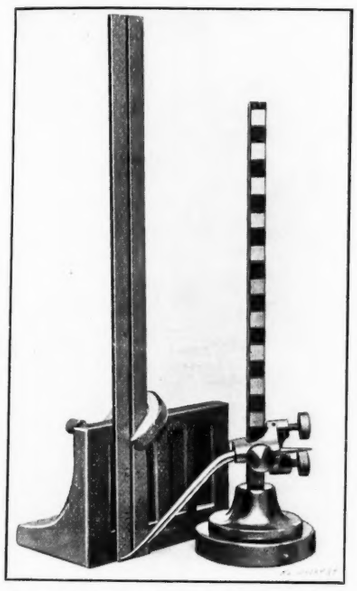


Fig. 1. Scriber-head used as a Surface Gage

Fig. 3 shows the construction of the scriber-head, which has an ingenious mode of adjustment. The head *A*, which

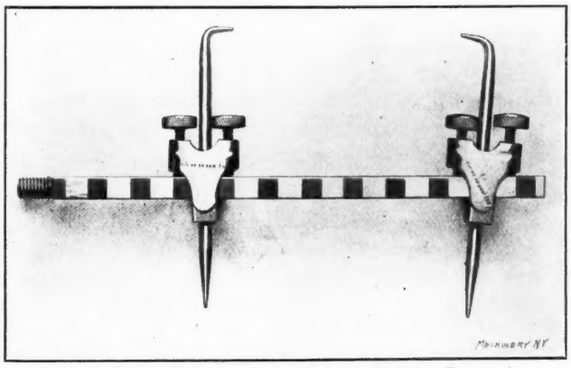


Fig. 2. Scriber-heads used on a Rod constituting a Trammel

is made of brass, has a rectangular hole cut in it to fit the steel bar *B* on two of its faces. A series of concavities are drilled on the under side of the bar *B*, and the rounded point of the screw *C* fits into whichever concavity happens to suit the desired position on the bar. The screws *D* clamp the head to the bar, and by manipulating them the head can be tipped in the required direction. These screws give the fine adjustment to the scriber point. In order to make the head follow the action of the adjusting screws instantly, a coiled spring is placed in the counterbored hole *E*, this spring pressing upon the face of the bar. The upper coil of the spring is straightened and inserted in the hole *F* to retain it in position. After the head has been tilted the required amount, it is securely locked by the screws *D*. When it is desired to shift the head along the bar, screws *D* are slackened slightly,

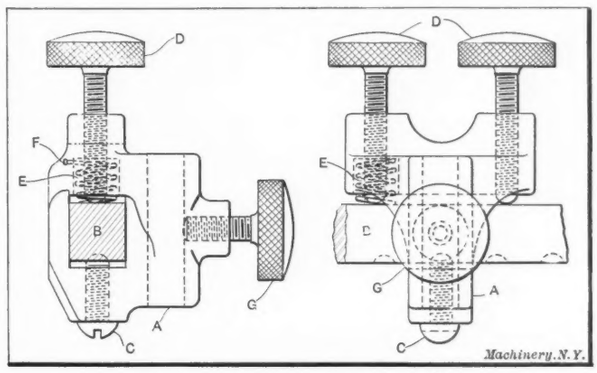


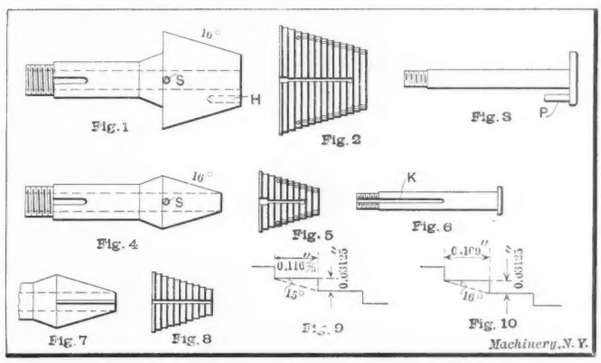
Fig. 3. Construction of the Scriber-head

and the head slid along until the screw *C* "clicks" into the required concavity. The screw *G* serves to bind the scriber in the scriber-head. A bent scriber, such as shown in Fig. 1, is sometimes used in place of the usual straight scriber. Various sizes of this tool are being manufactured to meet the requirements of different classes of fitters and machinists.

Bath, England. JOSEPH G. HORNER

EXPANSION CHUCKS FOR THE BENCH LATHE

The expansion chucks shown in the accompanying illustration are quite a desirable addition to a bench lathe outfit, especially for repair work on optical instruments, for it is frequently necessary to grasp a thin tube by the inside. The bench lathe to which these expansion chucks were to be fitted,



Figs. 1 to 10. Detail Views of the Parts of a Special Spring Expansion Chuck for a Bench Lathe

was already supplied with a reducer to take spring chucks of a smaller size than those regularly supplied with the lathe, and these small spring chucks had an auxiliary draw-spindle to pull them in, so this was used to pull in the bolts Figs. 3 and 6, used in connection with the expansion chucks.

The chucks were made in the step form, and in order to avoid too long a chuck, there were two taper plugs made of unannealed tool steel, as shown in Figs. 1 and 4. The pull-in bolts for each of these plugs are shown in Figs. 3 and 6, respectively, these bolts having an endwise motion only, in relation to the plug. This was accomplished in the case of the bolt in Fig. 3 by the pin *P* driven tightly into its head; this pin is free to slide in the hole *H*, Fig. 1. The bolt shown in Fig. 6 has a keyway *K* which engages with the point of the screw *S*, Fig. 4.

The chucks themselves were stepped shells of thin cast iron, shown in Figs. 2 and 5, there being four shells to go on the large plug, Fig. 1, and four others to go on the small plug,

Fig. 4. Each step on any of the shells was 1/16 inch larger in diameter than the next smaller step on the same shell, and the smallest step on the larger shell, Fig. 2, was 1/16 inch larger in diameter than the diameter of the largest step on the small shell, Fig. 5. One pair of shells like Figs. 2 and 5 contained all the exact 1/16-inch sizes from 1 3/4 inch down to 7/16 inch. Another pair contained steps intermediate between these, that is, all the 1/32-inch sizes from 1 23/32 inch down to 15/32 inch. Another pair had each of its steps 1/64 inch larger than those on the first pair mentioned, while the fourth pair had each of its steps 1/64 inch smaller; thus there was a step for each exact 1/64 inch in diameter from 1 3/4 inch down to 7/16 inch.

The first shells made had three equally spaced slits running from each end, one of the slits leading in from the large end having a wide opening for a short distance, as shown in Figs. 2 and 5, to accommodate the head of the driving screw *S*, Figs. 1 and 4, screwed tightly into the steel plugs. This seemed to work all right on the large shells, but on the small shells, Fig. 5, it was somewhat of a failure as a method of driving, for when a disk or washer, for instance, was held by its bore on the small end of a shell, and a cut was attempted at the outside diameter of the washer, there was considerable torsional stress set up in the split shell, due to the fact that it was driven at one end, while the resistance to the drive took place at the other end. Some of the shells were broken through this cause. Subsequently, a new set of the smaller shells was made, with but a single saw slit extending from one end to the other, as shown in Fig. 8, and this was driven by a key, or feather, set in the plug, and extending the entire length of the taper side, as shown in Fig. 7.

The driving key or screw must be so made as to be readily removed, as this is necessary when making a new shell with special steps, for instance, or in making a new shell to replace a damaged one, as the shell cannot be split until after all the lathe work on it is completed. The method of holding the key in place was to make it a nice close fit in the keyway in the plug, and then put a slight bend in the key before spring tempering. This made a key that was slightly bent when out of its seat, but that was straight enough for practical purposes when in the plug, as shown in Fig. 7. This straightening out of the key to make it enter the keyway put sufficient pressure against the middle of one of its sides and both ends of the other side to prevent it dropping out when the plug was not in use. The reason for using a screw head in the first place for driving was on account of its being so readily removed when required, and the feature of torsional stress was not considered until it became apparent in actual use of the chucks.

The commercial sizes of brass tubing in use in this country are mostly in sixteenths, but many foreign instruments have tubing that will not go on the sixteenth steps, and as there is very little expansion permissible on any one step, there was of necessity a large number of steps required in the set.

The plugs were turned to an angle of 15 degrees with the center line, and in order to get the shells the same thickness at each end, each step had to be 0.1167 inch in length (0.03125 ÷ tan 15 degrees) as shown in Fig. 9, but if making another outfit complete from the start, the writer would turn the plugs to an angle of 16 degrees and make the steps 0.109 inch in length, as shown in Fig. 10, which would be somewhat easier to handle in the making, as then the fraction of a thousandth would be eliminated.

WALTER GRIBBEN

Brooklyn, N. Y.

STANDARD PARTS FOR PILLAR DIES

A punch and die for blanking and piercing is illustrated in Fig. 1, the blanks produced being shown in the lower right-hand corner. This punch and die is in no way remarkable in itself; it only serves to illustrate the practice of one of the large typewriter manufacturing concerns, where all the punches and dies are made of standard parts, in so far as is practicable. The particular punch and die here shown is merely chosen to give a concrete example of this idea.

The plunger *A* and base *B* are both standard; two sizes have been found sufficient to handle nearly all the blanks used in this shop. For some very large blanks, special bases and plungers are necessary, but these are few in number. Guide pins *C* and bushings *D* are also standard in size; several lengths of guide pins are required, necessitated by the varying strokes of different presses used in the shop. A shelf *E* is provided on the base for fastening to the bed of the press. This shelf is secured by clamps and bolts which are standard, made in various sizes. A standard spanner wrench is used to tighten these bolts.

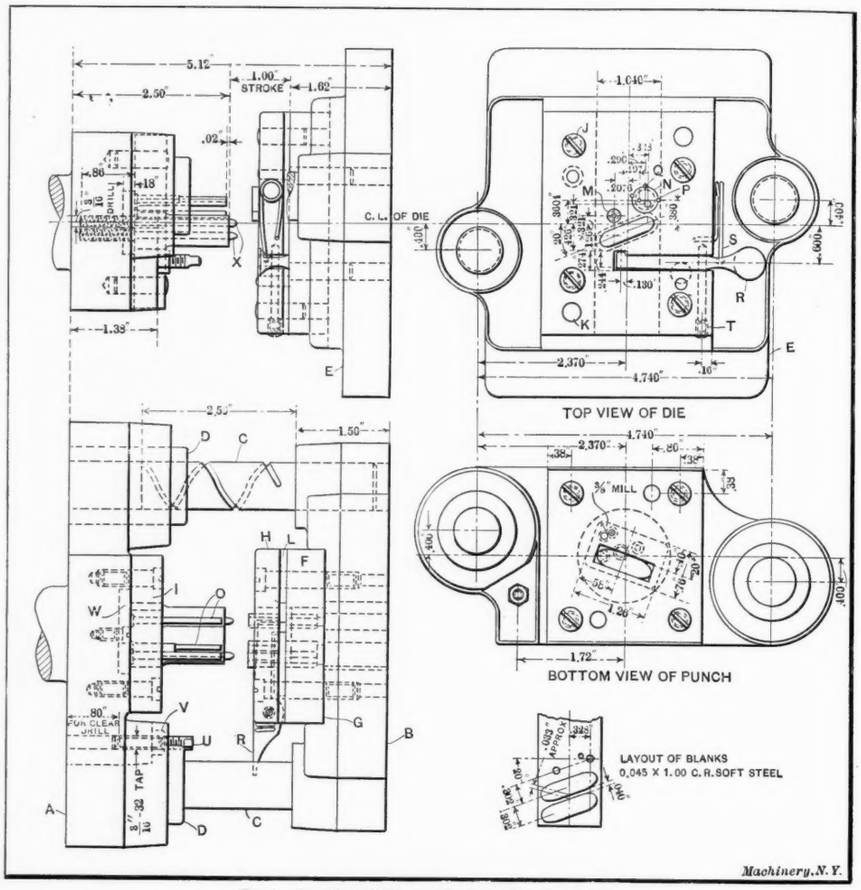


Fig. 1. Punch and Die made from Standard Parts

The die block *F* is tightly fitted in the recess *G*. The punch plate, die block, and the stripper plate are also standard. The former two, serving as very good examples of the method of standardization, are shown in the accompanying Tables I and II. This illustrates the method which is applied to as many of the punch details as possible. In Fig. 1, the punches are secured to punch plate *I*. The die and stripper are fastened to the base and are located, by screws *J* and dowels *K*, respectively. Guide strips *L* are provided, but these are not standard

on account of the varying widths and thicknesses of stock. Bushings *M* and *N* are provided in both stripper and die for supporting the slender piercing punches *O*. The bushing *N* is made with two holes and is secured against turning in the stripper by the pins *P* and in the die by the pin *Q*.

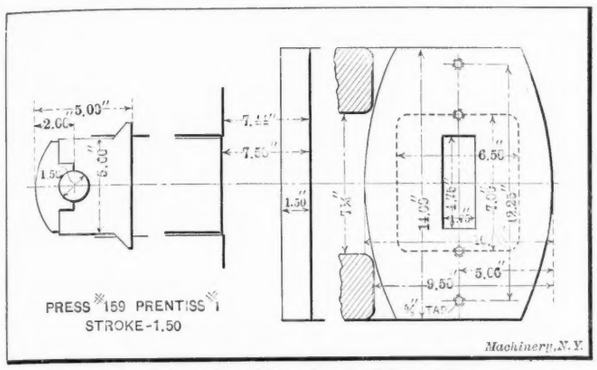
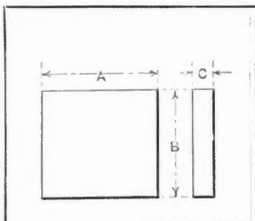
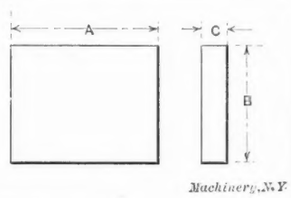


Fig. 2. Office Information Sheets showing Principal Dimensions of Presses for Convenience of the Die Designer

The stock is stopped against the feed stop *R*. This piece serves as another good example of the method of standardizing the die parts and for that reason is illustrated and tabulated in Table III. Two sizes are made. The spring *S*, screw pin *T*, and action pin *U* are also made standard in two sizes; a nut

TABLE I. PUNCH PLATES, M.S. TABLE II. DIE-BLOCKS—TOOL STEEL



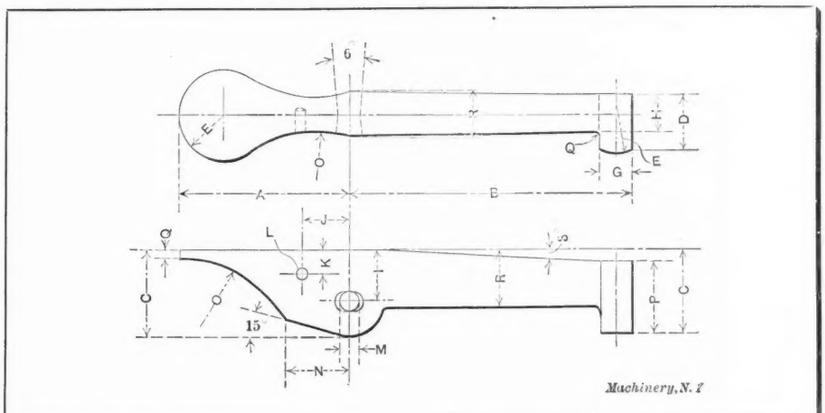


No.	A	B	C	Finished Sizes A	Finished Sizes B	Finished Sizes C	Rough Sizes A	Rough Sizes B	Rough Sizes C
1	$2\frac{3}{4}$	$2\frac{1}{2}$	$\frac{1}{2}$	$3\frac{1}{2}$	2.7396	$\frac{25}{32}$	$3\frac{1}{2}$	$2\frac{3}{4}$	0.63
2	$3\frac{1}{2}$	3	$\frac{1}{2}$	$4\frac{1}{2}$	3.4996	$\frac{25}{32}$	$4\frac{1}{2}$	$3\frac{17}{32}$	0.82

V prevents the latter part from turning. The punches are tightly fitted into the block *I*, and have their ends upset to prevent being pulled out, and a backing plate *W* of hardened tool steel acts as a good bearing. Spring pilots *X* accurately locate the pierced hole in the blank.

The prominent feature of this method of standardization is the fact that in making a die, such as the one just described, it is necessary to detail but very few parts, the dimensions shown in Fig. 1 being all that are required. Nearly all the parts are called for by a bill of material, shown in Table IV. which is added to the lower left-hand corner of the drawing. The parts required are thereby ordered directly from the stores department where all standard pieces are kept in stock for immediate use. The writer believes that nearly every shop would be benefited by the use of such a system.

TABLE III. DIMENSIONS OF FEED STOP



No.	A	B	C	D	E	G	H	I	J	K	L	M	N	O	P	Q	R
1	1.00	1.34	.48	.244	.20	.16	.17	.26	.28	.14	No. 2 .0635	$\frac{1}{8}$ slide	.36	.76	.42	.04	.20 slide
2	1.00	1.59	.50	.365	.26	.18	.23	.30	.28	.14	No. 48 .076	$\frac{1}{8}$ slide	.36	.76	.42	.04	.26 slide

TABLE IV. LIST OF MATERIAL NOT DETAILED

Quantity	St'd No.	Description
1	1	Feed stop }
1	1	Pin screw } Dr. No. 189.
1	1	Action pin }
1	1	Stop spring }
1	1	Die blank } Dr. No. 185.
1	1	Stripper }
1	1	Die block Patt. No. 515 } Dr. No. 188.
1	1	Punch block, Patt. No. 514 }
2	1	Guide pins, Dr. No. E 186.
2	1	Guide bushings, Patt. No. 505, Dr. No. 186,
1	1	Punch plate, Dr. No. E 190.

Quantity	Dia.	L'gth	Th'ds	Kind
4	$\frac{1}{4}$	0.88	0.24	Fil. head screws, C. H.
4	$\frac{1}{4}$	1.50	0.24	" " " "
1	$\frac{5}{16}$	0.38	0.32	" " " "
1	$\frac{3}{16}$	0.18	0.32	Hex. nut. "
2	$\frac{1}{4}$	0.82		Dowels, T. S., H., G., slide in punch block.
2	$\frac{1}{4}$	1.00		" " " " " " die block.
2	$\frac{1}{4}$	0.74		" " " " " " die.
2	$\frac{5}{32}$	0.48		Dowels, drill rod, H.
1	$\frac{9}{32}$	0.50		Pin, drill rod.
2	..			Springs, No. 17, 0.038 music wire, 15 sections, 14 working coils, open wound, 0.17 out. dia., 0.056 pitch.

Another very convenient scheme is employed in this same plant. This consists in supplying each of the draftsmen with a full set of drawings of the principal clearance dimensions of all the punch presses in the shop; one of these is shown in Fig. 2. This enables the designer to go ahead with the design, knowing just what conditions the punch and die will meet when set up. It also enables him to know at a glance what press it would be advisable to use for a certain punch and die.

C. A DINTER

A BABBITTING EXPERIENCE

That babbitt mine, so vividly described in the April number that I felt like writing to ask the author if he knew of any more mines and if there was any stock for sale, reminded me of a babbitting incident in a shop in a thriving Indiana town. This town has several steam and gas engine shops, but until recently it had not met with the favor of any machine tool builder, searching for a place wherein to produce his "best-ever" idea of a combination of pulleys, gears, spindles, slides, and beds, in concrete form. When an enterprising fellow with the machine-tool building "bug" came and located here, he found few men who had experience on machine-tool work, but he went ahead just the same, rented a building, set up his machines and hired a number of the men from the engine shops. Some of those hired were not machinists at all, but they said they were, and, of course, you ought to give a man the benefit of the doubt until proved guilty. Well, one of them proved guilty—or rather, he proved not guilty of being a machinist by committing a blunder the like of which I never heard of.

We were ready to test the first ma-

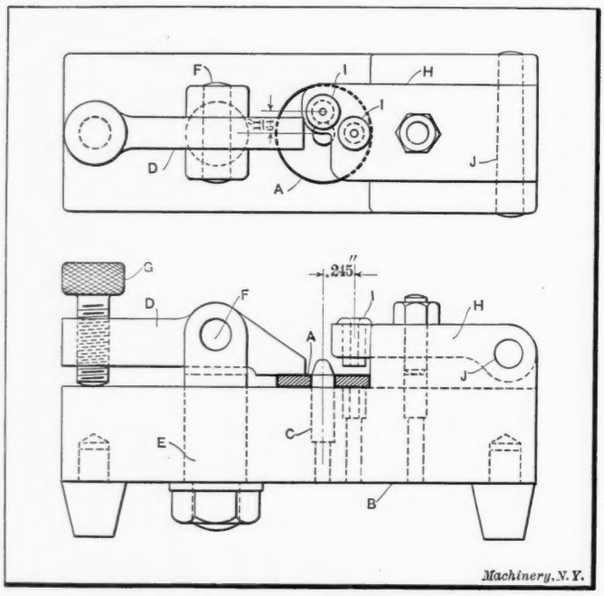
chine built, when the boss came around and happened to see a blowhole in the gear box casting, and as he wanted everything to look just right about *that* machine, he called upon one of the new "machinists" to see that the blowhole was filled. Some bearings were being babbitted at the other end of the shop, and our new man went over there and got a ladle full of babbitt and returned to fill the blowhole. Apparently, it was a mighty big blowhole, for he went back and got another ladle of babbitt, and about half of that, too, went into the blowhole before it appeared to be properly filled up. No one had paid any attention to the fellow, and when through he merely called the attention of the boss to the fact that the blowhole was filled.

And it was filled all right, as we were soon to discover! Shortly after we were ready to test the machines, and when the belt was adjusted, the power was turned on. We all stood around watching that machine like a baby taking its first steps. There was an ominous silence, a screeching of belts, a cracking roaring noise like that of a stone-crushing machine, and then a concerted lively movement to throw off the belt—but too late. All the teeth were stripped off the intermediate gear between the head and the gear-box. When we took the machine apart to locate the trouble, we found a "babbitt mine" in the gear box!

INDIANA

JIG FOR DRILLING AND TAPPING SMALL RATCHET WHEEL

The jig shown in the engraving was designed for drilling and tapping the small ratchet wheel *A*, shown in position. The jig consists of the base *B*, containing the locating pin *C*, on which the piece is centered by a hole previously drilled in the screw machine operation when the piece was cut off. It



Jig for Drilling and Tapping a Small Ratchet Wheel

will be noted that the holes are drilled and tapped before the teeth are cut.

The piece is held down by the swinging clamp *D*, pivoted in the post *E* on the taper pin *F*, and is adjusted by the screw *G*. The leaf *H* carries the bushings *I* through which the holes are drilled. It may be swung up out of the way on the pivot *J* for the tapping operation. When the piece is completed, by giving the screw *G* a half turn and swinging the clamp slightly, the work may be released. The jig is then ready for a new wheel.

C. A. DINTER

A CHALK PAD FOR DRAFTSMEN

Mr. G. J. Ney's article entitled "A Chalk Pad for Draftsmen," which appeared in the February issue of MACHINERY, has prompted the writer to send in a few lines on the subject.

The writer's practice has been to keep powdered chalk in a bag made of cheese-cloth or other loosely woven fabric, and simply rub the bag over the tracing cloth when it is desired to chalk the surface. This method works to best advantage when the bag is only from one-half to three-quarters full. The method followed in preparing these bags is to place the powder in a pile in the center of the cloth, draw the edges together and tie a string tightly around the top, trimming off the surplus with the shears. This forms an oval-shaped bag, similar to the common rubber tobacco pouch or purse, which is very convenient to use. Common dry lump starch has been used for dusting the linen when nothing else was available, with satisfactory results.

The hands of some men perspire to such an extent that it is a practical impossibility for them to keep a drawing clean. This difficulty can be very readily overcome by rubbing the hands with talcum powder, and it is surprising how dirty the hands may be and yet not soil the drawings, when talcum is used. This point came from a printer, and is one that might well be followed, especially in teaching drawing to students who work most of the time in the shop.

Greenfield, Mass. ALBERT L. GRAFFAM

FORMULA FOR KEYWAY MILLING

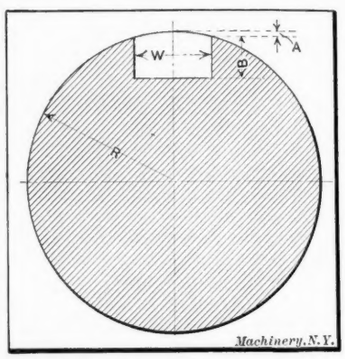
The formula given below is convenient to use for calculating the depth to which a milling cutter should be fed, in milling a keyway, from the point where it first touches the top of the shaft. The formula gives the height *A* of the arc, as shown in the illustration, and this is added to the actual depth *B* of the keyway. The formula is as follows:

$$A = R - \sqrt{R^2 - (\tfrac{1}{2}W)^2}$$

in which

R = one-half the diameter of the shaft.

W = width of keyway.



Notation used in Formula for Keyway Milling

Example: If the shaft diameter is 10 inches, then $R = 5$. Let the width of the keyway be 2 inches; then $\frac{1}{2}W = 1$. Hence,

$$A = 5 - \sqrt{5^2 - 1^2} = 5 - \sqrt{24} = 5 - 4.899 = = 0.101$$

Allentown, Pa. JOE V. ROMIG

RESTORING OVER-EXPOSED BLUEPRINTS

In the How and Why columns in the February number of MACHINERY, "Draftsman" asks for a method of restoring over-exposed blueprints. The following is a method which was used in an office where I was at one time employed. The man who was doing the blueprinting found by accident a method of restoring over-exposed blueprints without chemicals. The method consists in putting the print away after it has been over-exposed in a dark place for a few hours—three or four, or even over night—then wash it as though it had not been over-exposed. At one time we got a roll of paper which did not seem to print evenly, one edge seemed to become burnt before the rest was printed. This difficulty was overcome by over-exposing all the prints, then subjecting them to the dark treatment, and after washing, the prints were found to be all that could be desired.

JOHN A. WOOD

Los Angeles, Cal.

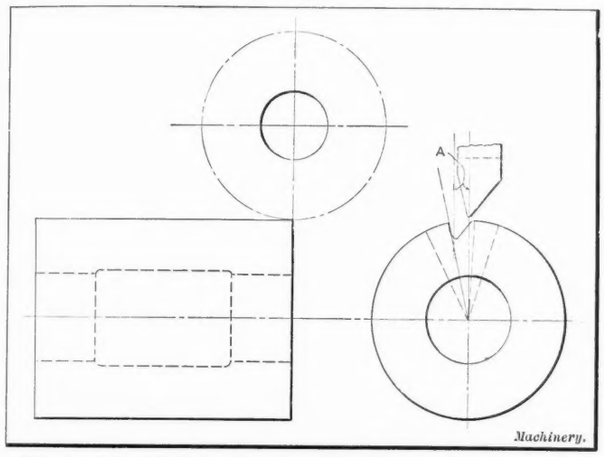
FLUTING SPIRAL MILLS

In the How and Why columns of the July number of MACHINERY, R. H. asks for the simplest and quickest method of setting a milling cutter for cutting the teeth in a spirally fluted milling cutter. The writer assumes that the information R. H. wants is that which will enable him to set the cutter so that the teeth of the mill will be radial on the cutting face. A great many mechanics simply put a mill that is similar to the one that is to be fluted between the centers

and set the cutter to this mill, and then replace it with the blank that is to be cut. This is the quickest and simplest method that the writer knows of. It is a crude approximation, however, and is not recommended where accurate results are desired.

The method that the writer follows is to set up the work in the machine, using the table of spirals furnished with the machine for gearing the machine and setting the table to the proper angle. When this is done, take a surface gage and set it to the same height as the center of the index centers, and put the work in the machine and the cutter on the arbor with the twelve-degree side next to the body of the machine, if the mill to be cut is right-hand, and outward, if it is left-hand; then set the cutter so that it is directly over the center of the end of the work on which the cut is to start, as clearly indicated in the accompanying illustration. This can be done by raising the saddle to the lowest position in which the cutter will just score the blank; then, with the traverse feed, move the work from under the cutter, and, using tissue paper as a "feeler," feed it back slowly. When the work just reaches that position in which the paper will be pulled or slightly torn, it is safe to say that the cutter is just over the center of that end of the blank.

With the table standing in this position, index the mill around and scribe off each tooth, letting the scriber marks appear only on that end of the blank where the cut enters. Having outlined each tooth in this way, mark the last line made and turn or index the blank 90 degrees, bringing the marked line to the top of the blank into a perpendicular



Figs. 1 and 2. Setting the Cutter for Fluting Spiral-tooth Milling Cutters

position. Now, since the angle on the cutter that produces the cutting face of the tooth on the mill is twelve degrees, it is evident that if the marked line that has been brought to the top is thrown over in the direction facing the twelve-degree side of the cutter just twelve degrees, it will be parallel to the twelve-degree side of the cutter, and all that is necessary to do is to feed the cutter into the work with its twelve-degree side cutting to the marked line and the other leaving the required amount of land between its cut and the line representing the face of the next tooth. To rotate the blank twelve degrees requires that the index crank be turned one and one-third turn, providing the index head is geared 40 to 1, as the majority of index heads are. Where it requires a different row of holes to index one and one-third turn than it does to index the number of teeth that are to be cut, the hole nearest to one and one-third may be used in the row of holes employed to index the blank, the error from this being in most cases entirely negligible.

In case the angle on the side of the cutter with which it is desired to make the cutting face of the tooth should not be 12 degrees, the amount to rotate the blank can be determined by the usual plain indexing formula. For instance, should the angle be 15 degrees, then the amount that the index handle would be turned would be $360/15 = 24$; $40/24 = 1\ 16/24$, or 1 2/3 turn.

As the amount which the saddle of the machine will have to be moved to get the mill in the proper position (shown at *A*) is governed entirely by the lines which have been drawn on the end of the mill, the importance of having the end of the mill directly under the center of the cutter is readily seen, for if it were not, the amount that the work would rotate, due to the spiral movement, would affect the accuracy.

This method has the advantage of being easily remembered and applied, and may be applied to any angle of cutter on any size blank, regardless of number or depth of teeth. It can also be applied in cutting straight-fluted mills with a double-angle cutter; in that case it is not necessary for the end of the blank on which the teeth are laid out to be under the cutter when sinking it into the work for the trial cut.

Watervliet, N. Y. D. TAPPAN

METHOD OF SETTING CUTTER FOR FLUTING SPIRAL MILLS

In reply to the inquiry of R. H. in the How and Why columns of the July number of MACHINERY, in regard to the simplest and quickest method of setting a double angle cutter

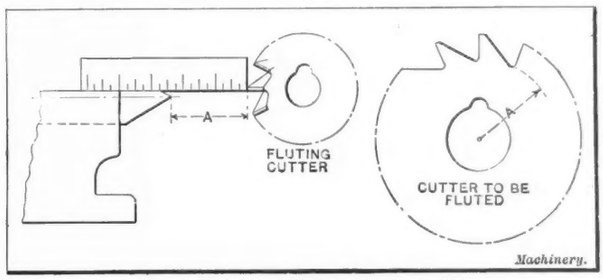


Fig. 1. First Step in Setting Fluting Cutter

for fluting spiral mills, the following practical method, used by the writer, is submitted:

After the fluting cutter is placed on the milling machine arbor, but before the work is put between the centers and before the table is swung over to the desired angle, raise the knee so as to bring the index centers approximately in line with the center line of the arbor. Then, by means of the table feed-screw, bring the point of the tail-center to such a location that its distance from the periphery of the fluting cutter is equal to the radius of the cutter to be milled minus the depth of the flute, as indicated in Fig. 1. Next, lay the scale upon the tailstock, pressing the edge against the beveled side of one tooth on the smaller angle of the fluting cutter, and then, by means of the cross feed-screw, shift the saddle over until the point of the tail-center coincides with the edge of the scale, as shown in Fig. 2. Then clamp the saddle, lower the knee, put the work between the centers, and swing the table

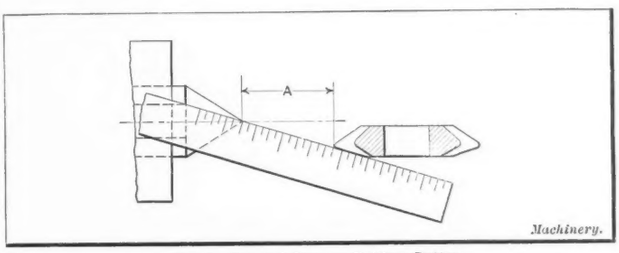


Fig. 2. Second Step in Setting Cutter

around to the required angle. The width of the land is now found by taking a trial cut for a short distance, and then indexing to the next tooth for a similar cut. Then index back again and repeat the operation until the desired width of land is obtained. The approximate depth of the flute (required for determining the distance *A* in Fig. 1) may be determined by measuring the depth of the flute on a similar cutter; or by a little practice it can be guessed at close enough for all practical purposes. This method is not mathematically exact, but as the inquiry is for a simple and quick method of setting the cutter, and not for the mathematical calculations for determining exact distances which are very difficult to measure at the machine, it is presented as a more practical method.

L. H.

FRICTION DISKS FOR CUTTING SOFT-STEEL SHEETS

In the How and Why columns of the April number of MACHINERY, G. F. Co. asks for information regarding friction disks for cutting soft-steel sheets. The best material from which to make friction disks for this purpose is soft steel which has a carbon content of about 0.15 per cent. A brand of steel called "soft-flange steel," which contains very little sulphur, gives satisfactory results.

The peripheral speed of the disk should not be less than 20,000 feet per minute; hence the diameter should be as large as possible to obviate heating the bearings. The disk is used without any abrasive whatever, but the surface should be provided with shallow cross grooves. When the sharp corners of the disk have become worn, it can be "sharpened" by taking a light cut from the periphery.

A large friction saw, in use in the shops of Joseph T. Ryerson & Son, Chicago, Ill., was illustrated and described in the June, 1905, number of MACHINERY. This saw, which is 52 inches in diameter, is made from ⅜-inch soft flange steel, and is run at a peripheral speed of 27,000 feet per minute.

G. MURRAY

Regarding the question by G. F. Co., in the April issue, I submit the following data on friction saws that may be useful: The proper material for the disk is soft steel, ordinary boiler plate, turned true, and roughened crossways on the edge with chisel cuts, 1/16 inch deep and about 1/4 inch apart. The peripheral speed should be about 20,000 feet per minute. The particular machine with which I am familiar is a rail saw. This uses a 42-inch disk running at 1800 R. P. M. It will cut through an 80-pound rail in about 12 seconds and requires 150 H. P. to drive it. The disks shows very little wear but will become slightly upset in time and requires to be trued up. It will probably be necessary to use a larger disk than the size stated, to secure the required surface speed.

Gary, Ind. H. J. MASTENBROOK

In the April number of MACHINERY in the How and Why columns there is an inquiry for a method of cutting soft-steel sheets with a rotary disk by friction. I notice that the G. F. Co. states that it has tried disks made of tool steel and found them too brittle for the purpose.

I would suggest that a soft wrought-iron disk be tried, using a quality of wrought iron similar to Swedish iron. I am not positive that it will be successful, as the material to be cut is soft also; but hardened tool steel may be cut easily with a wrought-iron disk running at a peripheral speed of from 8000 to 10,000 feet per minute, and a tool-steel disk will not do this, failing in the manner described by the G. F. Co.

Watervliet, N. Y. D. TAPPAN

AUTOMATIC LUBRICATION OF MACHINE TOOLS

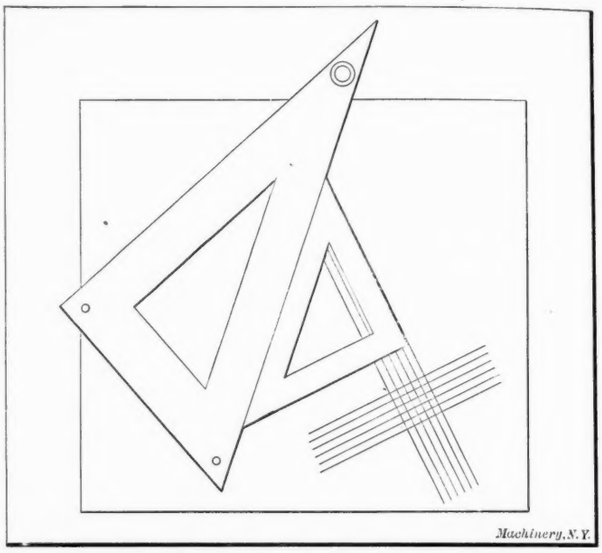
In regard to the editorial in your July issue requesting suggestions for articles that we would like to see in MACHINERY, would advise that if there is anyone who would see fit to publish recommendations on lubrication for machine shop equipment that will approach other up-to-date methods, we would appreciate them. There appears to be no two machine tool builders who have designed their machines with means for supplying lubrication, other than that depending on the judgment of the operators. We would like to see an account of an investigation that has been made relative to what is required in the way of lubrication of different machines, having bearings of various dimensions and operating at certain speeds. We find that in our shop the practice too often is to leave the lubrication to the judgment of the operator, which in some cases results in an excessive use of oil, flooding not only the machine, but the floor as well, while in other cases the bearings are allowed to go unoiled too long.

With so much talk at the present on scientific management, it would appear that someone should be able to give us some suggestions on scientific lubrication for machine tool equipment. J. G. W.

[American machine tool builders have not altogether ignored the subject of continuous or automatic lubrication of important bearings. A milling machine and boring mill on the market provide excellent examples of mechanical lubrication throughout.—EDITOR.]

DRAWING-ROOM KINKS

In the September number of MACHINERY is described a method for drawing such parallel lines as come out of the range of the forty-five- and sixty-degree triangles that are customarily used. To my mind there is a very serious objection to this method, as the three pins required to hold the triangle used as a base, would perforate the drawing, which would not be permissible in the majority of cases. A scheme which has been used successfully by the writer consists of drilling three holes in a large triangle, one near each corner; then, by putting a drawing pin in the hole which will give the most convenient swing and holding the opposite end, but little trouble should be experienced in drawing the required lines. As the engraving shows, the pin is inserted clear of the drawing. For making threads and small alterations, the use of a pair of three-inch triangles, one of which is held as a base, has been found to be the best method. If the operative triangle is arranged as shown in the engraving, both vertical and horizontal lines can be drawn at one setting.



Convenient Method of Drawing a Number of Parallel Lines

The following idea has been found very useful: Most draftsmen use two or three different grades of drawing pencils which have no distinguishing marks other than symbols on the end which are not always in a position to be readily seen. This usually means that two or three different pencils are picked up before the proper one is found. To distinguish the different grades, the following method is adopted: 2 H pencil is left plain; 4 H, notched all around the center, the notched part being blackened; and 6 H is notched and left unblackened. This method avoids confusion.

A good kink for users of steel scales is to slide the pencil or metal point down the graduation that marks off the required distance. This will prove to be a great time-saver, relieves the eyes and, in addition, gives more accurate results.

Woonsocket, R. I. KINGSTON FORBES

PAPER FILE HANDLES—PARALLEL TANGS

I would like to hear from those who have used paper file handles, if they like them as well as wood, or if they find them "sweaty" in the hand. As regards firmness of hold, all files should be made as Prof. Sweet advocated twenty-five years ago, with tangs having parallel sides. That would also lessen the trouble from splitting. R. G.

[We very much doubt that file tangs with parallel sides would prove satisfactory. Common machine shop practice shows that convenience of applying and removing file handles is an important consideration.—EDITOR.]

HOW AND WHY

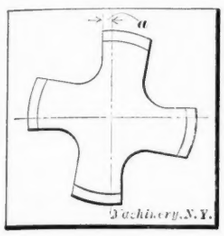
DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST

Give details and name and address. The latter are for our own convenience and will not be published

SETTING CUTTER FOR FLUTING TAPS

R. H.—How should the cutter be set for fluting taps?

A.—The actual methods for setting the cutter must vary according to the form of fluting cutter used, but as a general rule, applying to all forms of fluting cutters, it may be said that the cutter should be so set with relation to the tap that the cutting face becomes radial. This is the general practice for all taps used on steel or cast iron. When taps are to be used for brass, it is common practice to set the cutter so that the cutting edge is slightly in advance of the radial line, or in other words, parallel to a radial line, but ahead of the center, as shown in the accompanying illustration. This provides for a slight negative rake. The amount that the cutting face should be ahead of the center (dimension *a* in illustration) should be from one-sixteenth to one-tenth of the diameter of the tap.



MAKING BLUEPRINTS FROM BLUEPRINTS

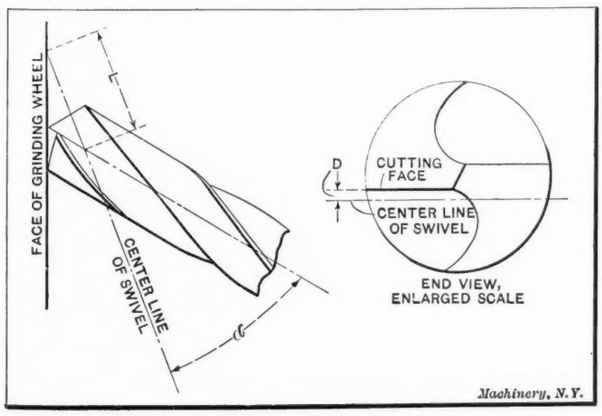
Answered by H. J. Mastenbrook, Gary, Ind.

In answer to Designer's query on, "Making Blueprints from Blueprints," which appeared in the How and Why columns of the March number of MACHINERY, the writer has to say that he has succeeded in doing this on several occasions. To obtain good results, a clear, sharp and rather dark print is essential, for if a print is blurred or light, it will not reproduce satisfactorily.

The method consists in coating the print with a little common kerosene and then printing immediately. The oil used will not affect the printing of the new print unless it is applied very thickly, and it will not spoil the original, as it soon dries out, leaving it in as good condition as before. This process will also work perfectly when it is desired to make prints from heavy drawings. It has been used with success to make blueprints from printed matter. To make the original perfectly transparent, apply a coat of paraffine, boiling hot.

DESIGN OF TWIST DRILL GRINDER

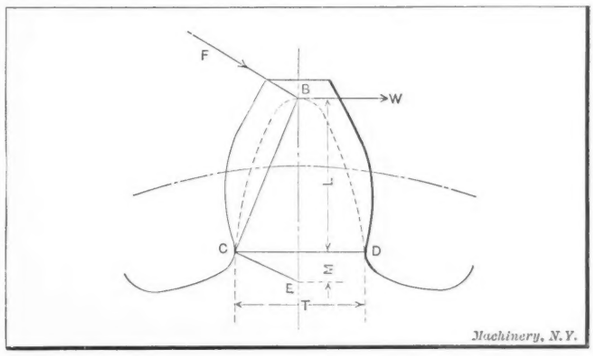
L. K. S.—The following questions relating to the construction of a twist drill grinder are submitted to the readers of MACHINERY: Referring to the accompanying illustration, what should be the angle *a* from the center line of the swivel of the drill grinder to the center line of the drill? What should be the distance *L* from the point where the center line of the swivel intersects the face of the grinding wheel to the point where the same center line intersects the center line of the drill? Give this information for all sizes of drills. What should be the distance *D* from the cutting face of the drill to the center line of the swivel for all sizes of drills?



STRENGTH OF GEAR TEETH—DERIVATION OF LEWIS' FORMULA

H. B.—Is there any commonly accepted rule for the strength of cast gear teeth? The Lewis formula for the strength and capacity of gear teeth does not exactly meet the requirements as it deals more particularly with cut gears, carefully designed and manufactured. How is the factor *Y* in the Lewis formula obtained?

A.—There is a great deal of discrepancy between the various rules published by different authorities, largely due to the many varying conditions met with in gearing, these conditions depending upon the materials, the methods of producing the gear teeth, the conditions of service, etc. It might be well said that no rule for the strength of gear teeth is complete unless it states definitely for what class of gears it is intended. For cut gears the Lewis formula is accepted as standard. For cast gears it would seem that the best method would be to use the Lewis formula so modified as to give a factor of safety two or three times that required by this formula, depending upon the severity of the conditions in each case. A general rule for cast gears, used under so many varying conditions, could hardly be satisfactorily devised. The designer's judgment must be depended upon to a considerable extent in the selection of the suitable factor of safety which will be required in excess of that required for cut gears.



As an indication of the uncertainty of the rules given by various authorities, Mr. Lewis mentions in his paper on the "Strength of Gear Teeth," read before the Engineers' Club of Philadelphia, October 15, 1892, and published in the proceedings of the club, January, 1893, that Mr. J. H. Cooper in making an investigation found that there were not less than forty-eight well-established rules in existence for the strength and capacity of gear teeth, these rules being sanctioned by twenty-four different authorities and giving gear teeth varying 500 per cent in ultimate strength.

The factor *Y* in the Lewis formula is deduced as follows: In the accompanying illustration a 14½-degree involute tooth is shown in outline. The pressure *F* transmitted to the gear tooth at an angle of 14½ degrees to a tangent to the pitch circle, may be considered as having two components, one of which is radial and tending to crush the tooth, and one tangential, tending to break off the tooth. The only component we need to consider in connection with the strength of gear teeth is the tangential component *W*. This component, as shown in the accompanying illustration, is not considered as acting upon the tooth at its top, but at the point *B* where the line representing the pressure *F* intersects the center line of the tooth. The line of pressure, of course, is considered as passing through the corner of the tooth as indicated.

Any parabola having the line *BE* for an axis and passing through the point *B*, so that the line representing force *W* is a tangent to the parabola at this point, encloses a beam of uniform strength. By graphical construction it can now be determined in each case where the point of tangency between the parabola and the contour of the tooth form occurs. The point of tangency determines the weakest section of the tooth.

as shown at *CD*. This weakest section is not necessarily at the very root of the tooth, but may—particularly in gears with a small number of teeth—be located a considerable distance above the root of the tooth; hence the distance *L*, the length of the beam, is measured not to the bottom of the tooth, but to the line *CD*.

In order to determine the value *Y* in the Lewis formula, draw the lines *BC* and *CE*, the latter being at right angles to *BC* and intersecting the center line of the tooth at *E*. In the following formulas:

S = the fiber stress,

A = the width of the face of the gear,

P = circular pitch of gear,

L, *M*, *T* and *W* denote quantities as indicated in the illustration.

Then we have:

$$WL = \frac{SAT^2}{6}, \text{ or } W = \frac{SAT^2}{6L}$$

But, by similar triangles,

$$M = \frac{T^2}{4L}$$

Hence

$$W = SA \times \frac{2}{3}M = SAP\frac{2M}{3P}$$

where $\frac{2M}{3P} = Y$, the factor in the Lewis formula.

BABBITTING BOXES

Answered by Charles Iselin, Newark, N. J.

In the "How and Why" columns of the July number of MACHINERY the writer noticed a query from J. P. regarding information on babbitting boxes; the writer wishes to submit the following methods, which from experience he has proved to be simple and easily applied:

Pillow blocks, which are usually very large, require a considerable amount of babbitt metal. They are customarily babbitted half at a time for various reasons, which are obvious and need not be mentioned. The method of locating and securing the babbitt arbor, which is usually a hollow cast-iron shaft, is necessarily governed by local conditions so any complete instructions for so doing cannot be given. As illustrative of performing such work the writer has selected

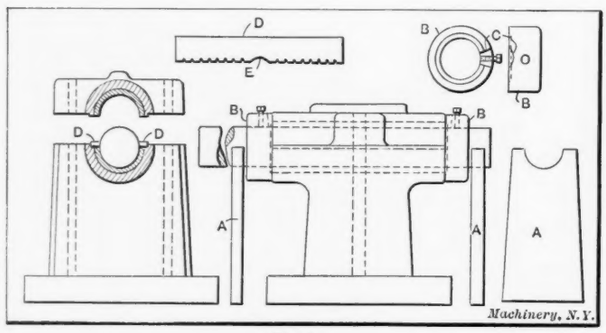


Fig. 1

a sample box which he had occasion to babbitt in a jobbing shop, where several engines had to be built on contract; this bearing is shown in Fig. 1. After determining the correct height at which to set the arbor for babbitting the block, two saddle pieces, such as are shown at *A*, are made and blocked up under the babbitting arbor with collars *B* at each end to locate them; these collars are slightly recessed on the inner faces in order that the babbitt may protrude a short distance from the end of the bearing. This permits the babbitt to shrink slightly, and at the same time leaves enough for peening over and finishing off to a good surface. These collars have a channel *C* cut in the top for pouring in the babbitt.

The end view in Fig. 1 shows the bearing set up to be babbitted in halves and the side view shows the bearing prepared to be babbitted as a unit. In the former case the arbor is located, the collar set up and two liners *D* set up against the shaft as indicated. These liners have a cut-out *E* into which the babbitt may be poured. When properly located all crevices and openings are stopped up with a coating of soft clay or putty, only the notched edge of the strips *D* are left to act as vents. These strips should be secured in place either by weights or by the regular bolt holes in order that the molten babbitt will not float them from their correct location. These liners leave the surface in a smooth condition with the exception of the little projections of the vent holes, which are readily removed with a keen-edged chisel. The use of the recessed collars becomes apparent, for without them the shrinkage of the babbitt metal would leave a slight recess at each end which is counteracted as mentioned. On large boxes, 1/16 inch is allowed for recessing, while on boxes 3 inches in diameter and smaller, 1/32 inch is found sufficient.

After the lower section of the bearing is babbitted, the upper section is thoroughly cleaned and placed in its correct

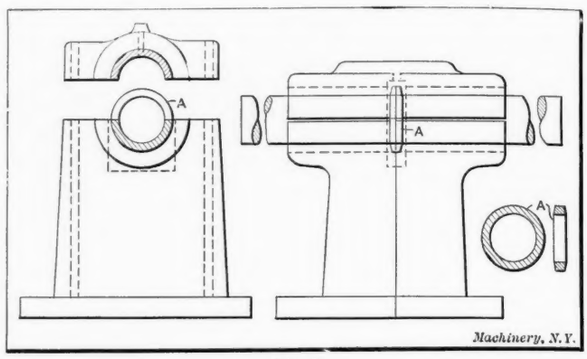


Fig. 2

location over the lower section with the regular liners intervening, care being taken that all the babbitt surface of the lower section is protected so that none of the molten babbitt of the top will reach it and thereby injure the surface. To facilitate the pouring of the metal it is advisable to build up a dam of clay or putty around the sprue opening *C*. When the box is completely filled with metal, pause for a few seconds until it is found that the metal has contracted sufficiently to allow a little more to be introduced. When the babbitt has solidified, the bearing is disassembled and all projecting fins scraped or cut off.

As previously mentioned, smaller boxes may be babbitted as a whole, as illustrated in the side elevation of the bearing in Fig. 1. In such a case temporary liners of the same thickness as the regular liners are inserted and the process proceeds as before. After solidification the cap may be taken off by driving a chisel or any kind of a wedge tool between the joint, when the little connecting tips occasioned by the intervening liners will break off freely, not injuring the main body of the metal.

The method of babbitting bearings which have an oil pocket for chain or ring lubrication, is carried on in a slightly different manner. A flared ring, as indicated at *A* in Fig. 2, is made to fit the babbitt arbor and facilitates the operation of babbitting; the tapered flare makes it possible for the box to be taken apart in halves after babbitting. Soft clay is used by many as a stopper for babbitting and may also be used to fill the oil pocket in the bottom half of the box. The writer's experience, however, has not been very favorable towards the use of soft clay, for, if it is a little too damp, the hot babbitt will sputter, not making a good job. A better method of procedure is to fill the oil-pocket with dry sand and, if necessary, use a little putty instead of the soft clay. It will be found by using this method that the babbitt will run much more smoothly, forming a neater job.

* * *

When screwing pipe into fittings, or "making up joints," the common practice is to put the joint compound on the pipe threads or in the fitting threads alone. An even distribution of the compound is rarely effected in this way and leaky joints are a common result. A better distribution of compound will be secured if it is put on both the pipe and fitting. While it takes somewhat longer to apply the compound in this manner, the number of leaky joints will be decreased sufficiently to make the practice pay.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

GARDNER VERTICAL-SPINDLE DISK GRINDER

An interesting development in disk-grinding machinery is illustrated in Figs. 1 and 2 which show front and rear views of what is said to be the largest disk grinder ever manufactured, as far as the diameter and weight of the disk wheel itself is concerned. This grinder is a recent product of the Gardner Machine Co., Beloit, Wis., and it is a development of the old horizontal lead lap, in that the principle of operation is the same; there is, however, a decided difference in the efficiency of this new machine, as well as in the class of work to which it is adapted.

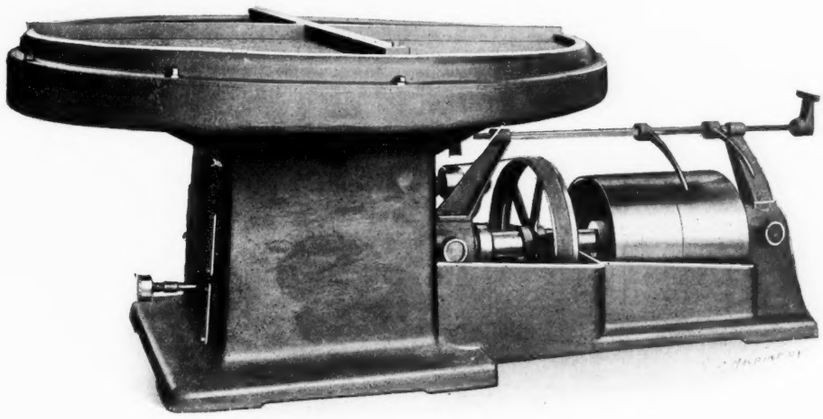


Fig. 1. Gardner No. 24 Vertical-spindle Disk Grinder

As will be noted, this new machine differs from the ordinary type of disk grinder in that the disk is mounted on a vertical spindle and revolves in a horizontal plane. The disk or wheel is 53 inches in diameter and weighs nearly 700 pounds. It is supported by an exceptionally large and heavy cast-iron flange, mounted on the vertical spindle which runs on a ball-bearing step. Power is transmitted to the wheel from a belt-driven horizontal shaft connecting, through bevel gears inside the base of the machine, with the vertical spindle. These bevel gears are of ample size and have planed teeth. One gear is of steel and the other of high-grade phosphor bronze, and both are tightly enclosed and run immersed in oil. This construction insures very quiet operation.

As the engravings show, the countershaft with its mounting forms an integral part of the machine. It is provided with tight-and-loose pulleys having a diameter of 14 inches and a face width of 8 inches. The countershaft also carries an 18-inch pulley for driving an exhaust fan which is set on the floor at the rear of the machine, as illustrated in Fig. 2. A tapering air passage, which is cast into the base, extends entirely around and underneath the outer edge of the wheel and terminates at the rear, where connection is made with the exhaust pipe and fan. In this way the dust incident to the grinding operation, is taken care of. The air passage is provided with openings directly beneath the outer edge of the wheel and these openings are graduated in size to produce an even draft of air all the way around.

A cast-iron ring is fastened to the top of the base with collar-head screws, as shown, and to this ring, different forms of work-holders may be secured. The particular work-holder illustrated is simply a cross made of bars of hard wood and is intended for holding four parts simultaneously. Owing to the size of the disk-wheel, four pieces of considerable size may be held, such as foundry flasks, gear-cases, etc., having diameters up to 18 inches, or rectangular shapes measuring 16 by 18 inches. For still larger castings a single bar may be fastened across the center, thus enabling two large pieces to be ground at the same time. When very large castings need to be ground, these can be held by two short bars at the sides.

In operating this machine, the work is simply laid on the revolving disk. If the weight of the work is equal to three or four pounds pressure to the square inch of area to be finished, no additional pressure is required, but in case it is less than that, the output can be greatly increased by putting additional weight on top of the work. Fig. 3 shows the machine grinding three-horsepower gas-engine base castings, four of these castings being placed on the disk and ground simultaneously. This particular operation was simply to produce a flat even bearing surface without removing any unnecessary stock. The time for doing this work is about one minute per casting. This machine is also very efficient for many kinds of free-hand grinding, no effort being required to support the work, and tests made with different classes of work are said to have shown very efficient results.

The abrasive disks used on this large wheel are made in halves or semicircles; these are cut from sheets 27 inches wide, which, until recently, was about the maximum width obtainable. The abrasive disks are held against the wheel, while being cemented, by a pneumatic diaphragm press. The wheel also remains permanently on its spindle, as it would be difficult to remove without using a crane, owing to its weight. This press, which is shown attached to the grinder in Fig. 4, consists principally of a sheet-metal cone having a diaphragm made of heavy air-proof canvas, cemented to the bottom. When applying the press, the cast-iron shield ring is first removed from the base; the abrasive disk is then placed on the cement-coated wheel, after which the diaphragm press

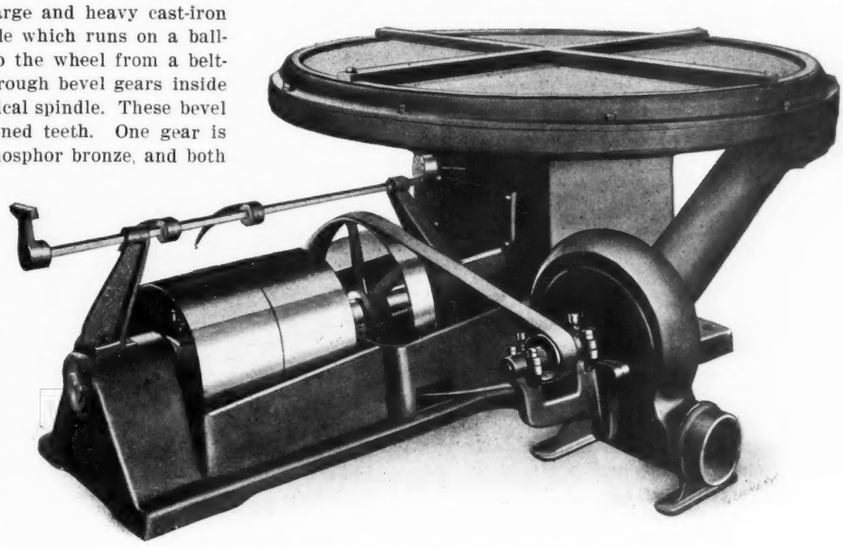


Fig. 2. Rear View of Vertical-spindle Disk Grinder showing Dust Exhaust Fan

is laid on top. The press is clamped to the wheel around the outer edge, as shown in the illustration, and air is pumped into the cone-shaped enclosure with a bicycle pump, until the gage shows a pressure of about two pounds. The press is kept on the wheel and the pressure is maintained for about two hours. Any slight leakage of air will show on the gage,

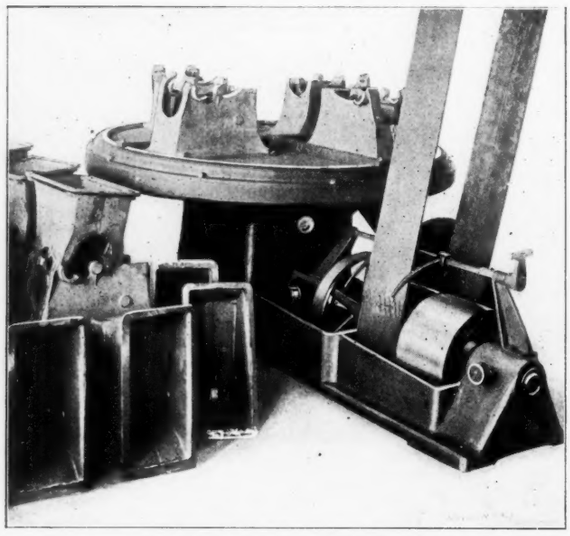


Fig. 3. Four Gas-engine Base Castings being ground simultaneously on Vertical-spindle Disk Grinder

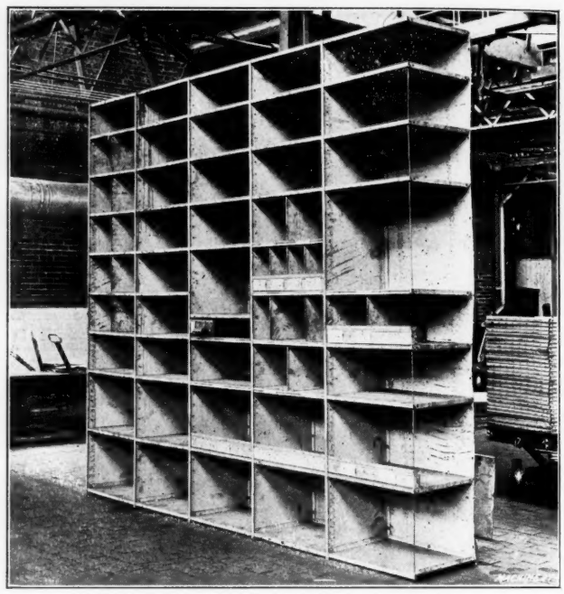
and if this occurs, the pressure should be kept up to the two-pound mark by additional pumping. To remove the press, the air is first blown off by means of an air-cock, before loosening the clamps. This new method of cementing the disks gives a uniform pressure over the entire surface of the wheel and

Fig. 4. Pneumatic Diaphragm Press used when cementing Abrasive Disks to Wheel of Vertical-spindle Grinder

the required pressure is easily obtained; in fact, this new diaphragm press is said to have made the immense increase in the size of disk-wheel practicable.

BERGER'S SECTIONAL STEEL BINS

The use of steel bins for the storage of material in the shop or foundry not only effects a saving in space but affords considerable protection from fire. A steel bin of the sectional type, for which many advantages are claimed, has been brought out by the Berger Mfg. Co., Canton, O. This type of bin, a section of which is shown in the accompanying illustration, with the end upright removed, is so constructed that each shelf is independently adjustable to different heights and locations to accommodate large patterns, castings, cores, etc. In fact, these shelves can be arranged to suit any of the numerous articles in everyday use in the shop or foundry. Removable bin boards are also supplied to order for retaining small parts in compartments that are filled to their capacity. The vertical partitions, which may be quickly put in position, also add to the utility of these steel bins. Label holders extend the entire length of each shelf so that no matter where a shelf is located or how it is sub-divided, these continuous holders afford a place to easily and plainly mark the contents of each division. Extensions can be added to the lower bins to make them deeper and more roomy, and these at the same time form a convenient shelf on which to rest boxes or heavy articles that are either in use or being placed in the upper shelves. Regular bin boards can be used for these extensions. The shelves are so constructed that each one forms a brace by the manner in which it is fastened to the permanent upright partition, so that each shelf adds to the



Sectional Steel Bin built by the Berger Mfg. Co.

strength and stiffness of the entire structure. As the illustration shows, the space within the bins is entirely free from braces and supports, thus giving a maximum storage space.

BROWN & SHARPE CASTELLATING ATTACHMENT

Automobile manufacturers and others building machinery requiring locking nuts will doubtless be interested in the new attachment brought out by the Brown & Sharpe Mfg. Co., Providence, R. I., for use on the No. 2 automatic screw machine. This attachment is designed for the purpose of castellating hexagonal nuts after the latter are cut from the bar, thus finishing them completely in the same machine. In this way an appreciable saving in time and labor is effected, and the necessity for special machines to do this work is obviated. The attachment is a compact, efficient, mechanism and can readily be placed in position or removed from the machine when not in use.

The accompanying engravings show front and rear views of the attachment. The mechanism consists of a set of three saws for slotting the nuts, an indexing mechanism for locating the nuts in the proper positions to be slotted, a feeding mechanism for the cutters, and a transferring arm for taking the nuts as they are cut from the bar and carrying them to the attachment. With the exception of the saws, the mechanism is driven from the cam shaft of the machine. The saws are driven directly by a belt from the overhead works. The nuts to be castellated are inserted in the bushings held in a magazine plate fastened to a sleeve on the main spindle of the attachment. Different sizes of bushings can be furnished to accommodate different sizes of nuts, there being a capacity for nuts measuring from 9/16 inch across flats and 3/8 inch thick, to those measuring 7/8 inch across flats and 5/8 inch thick. There are six bushings in the plate.

The operation of the attachment is as follows: As the nut is cut from the bar, the transferring arm *A* takes it and swings back to a position opposite a bushing in the magazine plate *B*. When the arm swings back, or into position facing the plate, a flat spring *C* rotates the nut so that its position is correct relative to the hole in the bushing of the plate. The arm then moves forward until the small pin that extends radially from the stud upon which the nut is carried, comes in contact with its stop. The arrangement for carrying the nut consists of a stud that is inserted in a bushing and is forced forward by a spiral spring. As the pin referred to reaches its stop, the bushing is forced further forward by the arm, with the result that the nut carried on the end of the stud is pushed off and into the hexagonal hole in the bushing in the plate. At the same time, a nut that has been castellated is pushed out at the back of the plate bushing by the entering nut. As soon as the nut has been inserted, the mechanism indexes and the plate is moved one-sixth of a revolution; then it is in a position to be slotted by the first cutter. While it is being slotted, another nut is being inserted by the transferring arm. When the mechanism indexes again, the first nut is moved to a position midway between the first and second cutters. At the next indexing, the plate has moved one-sixth of a revolution further, or one-third of a revolution from the first cutter, bringing the first nut in a position to be cut across by the second cutter. Two more indexings bring the nut into position to be operated on by the third cutter and at the end of the following indexing, the finished nut is ejected from the plate at the starting point by a new nut that is being inserted.

The sprockets and chain that drive the indexing and feeding mechanism are shown in the front view Fig. 1. The indexing mechanism consists of a segment of a gear mounted upon the shaft driven by the sprocket chain. Each time this segment revolves, its teeth engage with a gear fastened to the main spindle sleeve of the attachment and move the plate

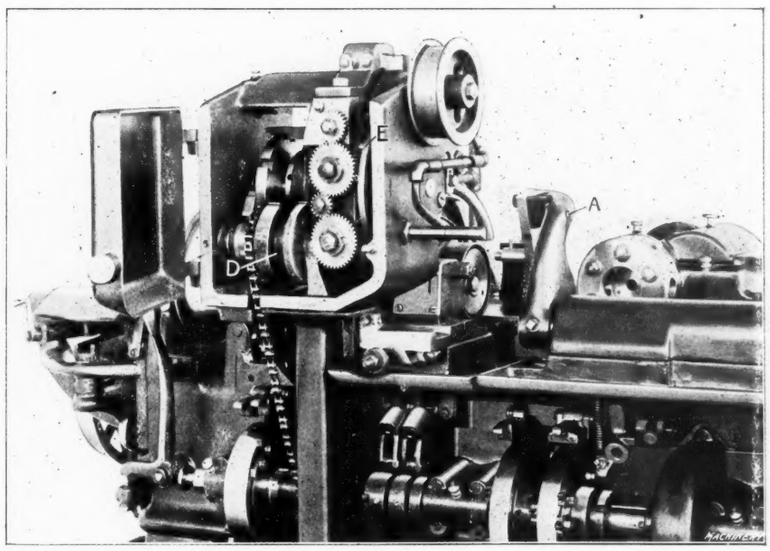


Fig. 1. Castellating Attachment applied to Brown & Sharpe Automatic Screw Machine

holding the nuts one-sixth of a revolution. When this movement has been made, the cylindrical cam *D* on the sprocket wheel shaft, proceeds to feed the geared head carrying the cutters forward. As it does so, the plate holding the nuts is positively locked in position. A pressure plate *E*, is mounted on the geared head to securely hold the nuts in the plate while they are being slotted. It has three slight projections which bear upon the nuts as they are operated upon by the cutters. The cutters extend through slots in this plate, and the plate is held firmly against the nuts by springs. This plate automatically compensates for any variation in the nut due to the amount of burr left from cutting off.

From the foregoing, it is seen that the operation of castellating a nut consumes the time of milling one slot and indexing the disk one-sixth of a revolution. It has been found that the time required for making the nut in the machine itself gives ample time for this sawing and indexing. With this attachment, the Brown & Sharpe Mfg. Co. has produced as many as a thousand nuts a day and the saws have been run for ten days without grinding.

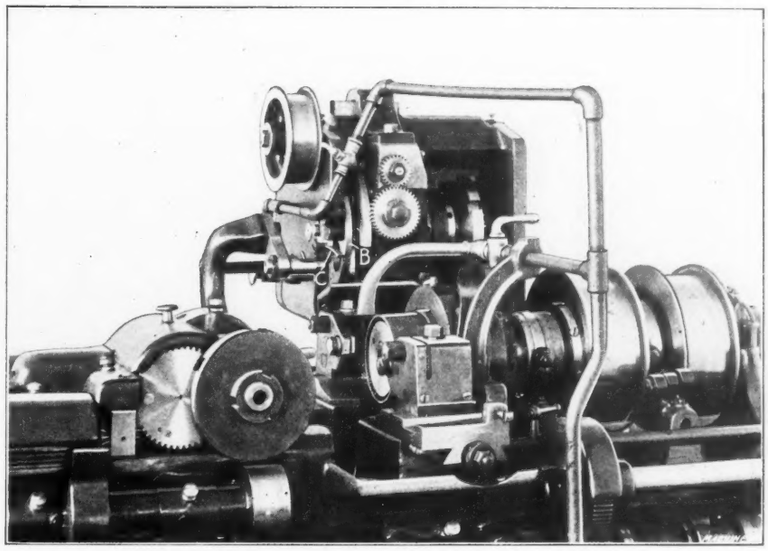


Fig. 2. Rear View of the Brown & Sharpe Castellating Attachment

GOULD & EBERHARDT WORM-WHEEL HOBBING ATTACHMENT

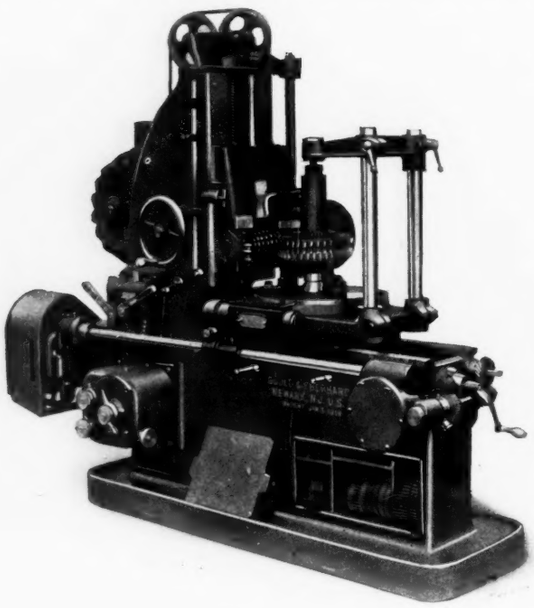
The accompanying illustration shows a 24- by 8-inch spur and bevel gear cutting machine arranged with an automatic worm-wheel hobbing attachment and constant-speed motor drive, as designed and manufactured by Gould & Eberhardt, Newark, N. J.

The design of the vertical cutting machine is well adapted for the hobbing attachment, and, as arranged, the attachment does not interfere with the regular operations of the machine. The hob is mounted on the vertical cutter slide, and the latter is adjusted so that the center of the cutter arbor is in line with the center of the worm blank to be cut, and it is securely locked in this position. In order to insure that the cutter slide feed or return clutch does not engage and move the hob out of position, thus spoiling the blank, a safety pin has been provided to hold the trip lever and clutch in the proper position. The direct-reading cutter-slide feed dial can also be placed at zero, at which point the cutter-slide feed gears are disengaged which doubly prevents the cutter slide from feeding.

A chart is furnished for gearing the index mechanism, the same as for spur gears, according to the number of teeth in the worm-wheel, for maintaining the proper relation between the hob and the work. The feeding in of the blank is automatically taken care of by means of a feed lever and pawl which derives its motion from the worm-shaft through a worm and worm-wheel. The amount of feed per revolution of the blank may be changed by means of a cam and dial graduated in thousandths. The blank is then fed in to the proper depth of tooth. A dial, graduated in thousandths, is provided on the table feed-screw, and a scale and vernier are

also furnished on the side of the machine, which allows the operator to ascertain at any time the exact center distance between the cutter spindle and the work mandrel. The machine is shown in the illustration cutting a steel worm-wheel having thirty-six teeth of ¾-inch circular pitch and a 2½-inch face width.

When the hobbing attachment is not needed, the worm on the worm-shaft, that imparts motion to the in-feed mechanism, may easily be disengaged, so that these parts do not



Gould & Eberhardt Automatic Gear-cutting Machine with a Constant-speed Motor Drive and Worm-wheel Hobbing Attachment

rotate and become worn when the machine is being used for cutting spur and bevel gears. There is an adjustable safety guard over the driving pulley, and all running gears are enclosed with guards.

PRATT & WHITNEY QUICK-ACTION MANUFACTURERS' VISE

A new type of vise that is particularly adapted to milling machine work, has recently been placed on the market by the Pratt & Whitney Co., Hartford, Conn. This type of vise has been used extensively and with unusual success by this company in connection with milling operations and especially for gun work. The design of the vise is very compact, and in operation it has practically the rigidity of a solid casting.

The operation of the vise is exactly opposite to the ordinary screw vise in that the inner or central jaw, against which practically all of the working strains come, is bolted stationary and the outer jaw is movable. The outer jaw-holder, which is made from a steel forging, passes underneath

Fig. 1. Pratt & Whitney Quick-action Manufacturers' Vise

and is supported by the stationary jaw, and it is actuated by a hardened cam which is forged integral with the operating lever. The form of the cam is such as to give a very rapid and efficient binding action and at the same time a wide opening to the jaws. The construction is such as to easily permit the removal and insertion of special jaws.

The vise is made in either single or double sizes, as shown in Figs. 1 and 2, respectively, and it is suitable for the Pratt & Whitney hand, No. 2 column power, and Lincoln milling machines. When made double, one set of jaws is supported by a wedge, as shown, by means of which a vertical adjustment is obtained to compensate for any variation of milling

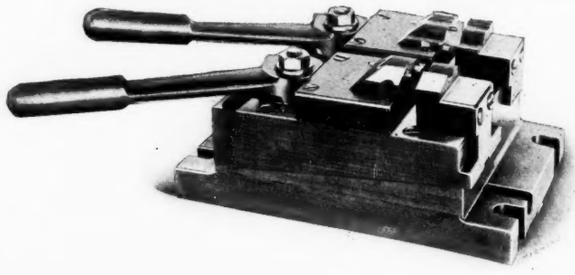
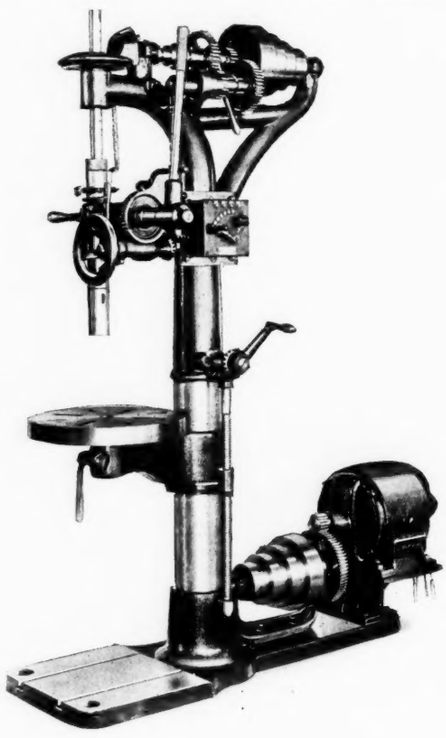


Fig. 2. A Double Vise with Vertical Adjustment for One Set of Jaws

cutters due to uneven wear. The vise may readily be arranged to accommodate a large variety of work by means of special jaws. These vises are regularly furnished without jaws.

SIBLEY MOTOR-DRIVEN DRILLING MACHINE

A recent addition to the line of drilling machines manufactured by the Sibley Machine Tool Co., No. 8 Tutt St., South Bend, Ind., is illustrated herewith. This is a new design of 20-inch motor-driven upright press. The motor is mounted on the base at the rear and drives direct through gearing to the lower cone pulley as the engraving shows.



Sibley 20-inch Motor-driven Drilling Machine

This arrangement brings the weight down low and adds to the stability of the machine.

All the working parts are generously proportioned and there is practically no spring between the head and table arm, as both of these parts have been made strong enough for much heavier work than the capacity of the press. The back-gears have a ratio of about 4 to 1, which, in conjunction with 2 to 1 driving gears and large cones, delivers ample power to the spindle.

The feed worm-gear is driven by a steel worm running in an oil bath which insures constant and thorough lubrication.

A steel feed lever is provided which is light enough for sensitive work and at the same time strong enough for heavy drilling operations. The change from lever to wheel feed is effected by a slight twist of the lever, and both feeds are independent of each other. An adjustable automatic stop collar on the spindle sleeve trips the latch which releases the worm-box lever and the entire mechanism swings away from the worm-gear on a hinge-pin, thus disengaging the feed. This worm-box lever also provides means for taking up any wear of the worm or worm-gear which may occur. The vertical feed shaft is driven by a worm-gear and worm running in oil, and the worm derives its power from the top shaft through a cone pulley.

Particular care has been given to the finish of this machine, the spindle and sleeve bring ground and other parts polished. All rough surfaces are painted with egg-shell enamel. This design is made with or without back-gears or power feed, and it may have either a geared or belted motor drive, reversing countershaft, or a geared tapping attachment. The 20-inch machine drills to the center of a 20¼-inch circle. The feed of the spindle is 8 inches; the maximum distance from the spindle to the base, 41½ inches; and the maximum distance to the table, 24 inches. The hole in the spindle is a No. 3 Morse taper. The diameter of the table is 16½ inches; diameter of the spindle 1¼ inch; and the diameter of the column, 5¼ inches. The shipping weight is 650 pounds.

INGERSOLL CUTTER GRINDER

An improved type of cutter grinder, designed to sharpen the large inserted-tooth milling cutters now used so extensively, with the same degree of accuracy as the smallest size within its range, is now being built by the Ingersoll Milling Machine

Fig. 1. Twenty-four inch Cutter Grinder built by the Ingersoll Milling Machine Co.

Co., Rockford, Ill. This machine embodies several interesting and original features, and it has a capacity for grinding face milling cutters ranging from 4½ to 24 inches in diameter and with widths varying from ⅛ to 4 inches. In addition, it will grind either the face, side, or corner of any milling cutter within the range given, at one setting of the cutter, thus saving the time that would otherwise be required for the re-setting operation. The corner of the cutter may be ground either round or angular in shape, and cutters of any angle can also be sharpened on this machine at one setting. Provision is made for wet grinding, and the arrangement is such that the cooling fluid is not thrown about the floor.

The construction of this grinder and its operation will be explained in connection with Figs. 1, 2 and 3. The cutter to be ground is mounted on an arbor *A* which is carried in spindle *B*. As this spindle revolves on a ball bearing, it has a sensitive movement so that the cutter tooth being ground is easily guided against finger *H*. The work-spindle is mounted in a quill *D* which may be adjusted vertically by pinion *E*,

Fig. 2. Cutter Grinder in Position for Grinding Side of Cutter

and the work with its spindle and quill is carried by a saddle *F*. This saddle has a horizontal adjustment along slide *G*. and the handwheels for both the vertical adjustment of the quill and the horizontal movement of the saddle, are graduated to thousandths of an inch. This horizontal and vertical movement is all that is necessary to place the cutter in the proper position for grinding. The emery wheel *I* is mounted on a spindle *J* which revolves in bronze bushings *K*, having a taper cone *L* to take up lost motion, if necessary. The spindle is carried in a sleeve *M* which has a vertical movement of 5 inches effected by means of the counterweighted lever shown in Fig. 1. The sleeve carrying the spindle is, in turn, mounted in a saddle *N* having a hand adjustment of 1½ inch operated by handwheel *O* which is also graduated to thousandths of an inch. This saddle, with the grinding head, is carried by a counterweighted yoke *P* mounted in roller bearings. This yoke, the counterweight for which may be seen at the side of the machine in Fig. 1, can be swung through an arc of 90 degrees from the horizontal to a vertical, and its angular position at any point is shown by quadrant *R*, which is graduated in degrees. This angular adjustment of the grinding head makes possible the sharpening of the cutter at one setting. Two stop or guide-fingers *H* are furnished for grinding either right- or left-hand cutters, and by means of a center gage, these fingers are set for grinding the proper degree of clearance. There are also four radius gages furnished, three of which are for grinding corners to a radius of ⅛, ¼, or ⅜ inch, and the fourth is for grinding a square corner. The method of setting the center and radius gages will be described later on.

When the cutter has been set and the finger adjusted, the operation of grinding consists in holding the tooth against the finger stop with one hand and feeding the grinding wheel across the face of the tooth with the other. This operation is repeated for each successive tooth until all are ground on the

face; the yoke or grinding head is then swung over 90 degrees, or to whatever angle is desired, and the side of the tooth is ground in the same manner. Fig. 2 shows the position of the grinding head when the yoke is in the 90-degree position. For grinding angular cutters, the yoke is simply set to the desired angle, as shown by the quadrant, and the operation as described for grinding the sides and faces of the teeth is followed. When "round corners" are to be ground, the spindle sleeve is locked by a stop on the yoke, and the radius

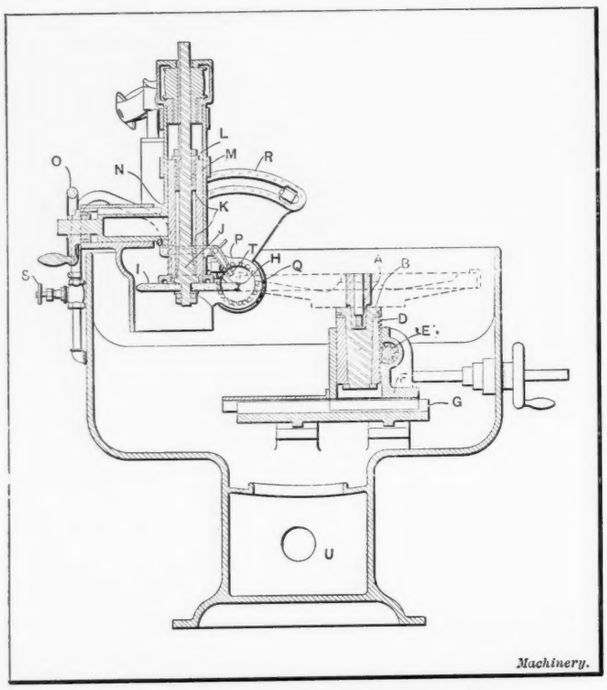


Fig. 3. Sectional View of Ingersoll Cutter Grinder

gage to which the cutter is set determines the radius of the corner of the tooth. This corner is then ground by swinging the counterbalanced yoke over each tooth. When the teeth are being ground, a flow of cutting fluid, regulated by valve *S*, is directed on the cutter through nozzle *T*; the fluid

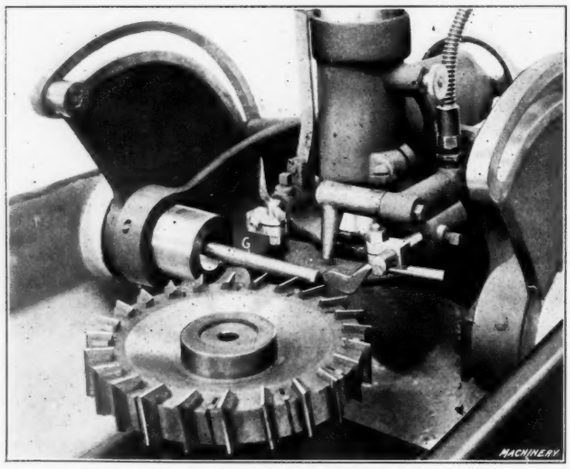


Fig. 4. Method of Setting Guide Finger for Clearance

then drains to tank *U* from which it is again pumped to the work.

The method of using the center gage, previously referred to, for setting the guide finger to obtain the proper degree of clearance is illustrated in Fig. 4. This gage *G* is inserted through a hollow bearing supporting the yoke, and its end lies in a vertical plane passing through the centers of the spindles which carry the grinding wheel and the cutter being ground. The distance that the index finger is set from the end of this gage determines the angular clearance of the tooth, and this distance, for cutters of different diameters and for various angles of clearance, may be ascertained by referring to a suitable table.

The method of setting cutters by means of radius gages for rounding the teeth, and also a quick method of grinding square corners, is illustrated in Fig. 5. Right-angle sections that are

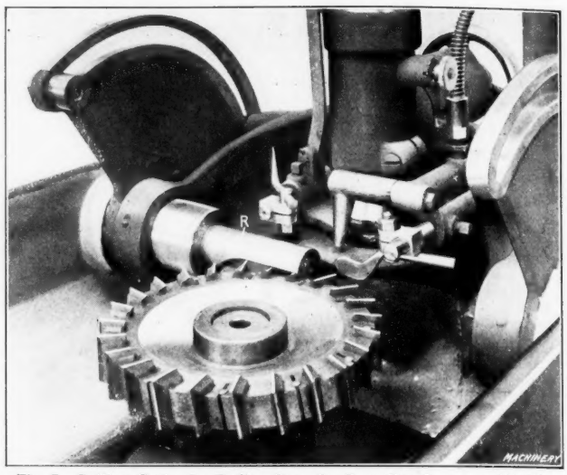


Fig. 5. Setting Cutter by Radius Gage for Rounding Corners of Teeth

⅛, ¼, and ⅜ inch off center (depending on the radius) are milled from the ends of these radius gages, and when a corner of ¼-inch radius is desired, for example, the gage *R* having a right-angle section ¼ inch off center, is inserted through the hollow bearing of the yoke, as shown. By means of the horizontal and vertical adjustment provided, the tooth of the cutter is set into this milled section of the gage; the latter

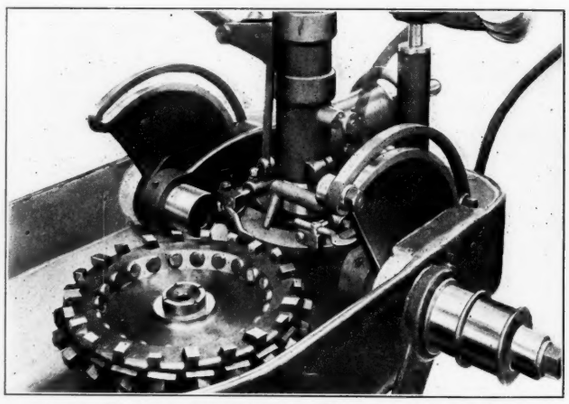


Fig. 6. Machine set for Grinding a Heavy Inserted-tooth Cutter

is then withdrawn and the cutter is ready for grinding. This operation, as previously stated, is performed by swinging the entire yoke and grinding wheel over each tooth. A quick setting for grinding a square corner is obtained by using a gage, from the end of which a quarter-section is milled,

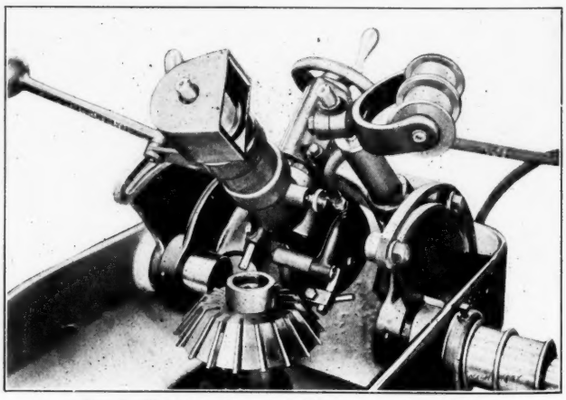


Fig. 7. Machine set for Grinding an Angular Cutter

the method of adjusting the cutter being the same as for round corners.

Fig. 6 shows the machine set for grinding an 18-inch

inserted-tooth heavy-type face mill. It is when grinding such large and heavy cutters as this, that the sensitiveness of movement resulting from the ball bearing mounting of the work-spindle, is particularly advantageous. In Fig. 7 the machine is shown set for grinding an angular cutter. The operation of setting consists in adjusting the yoke to the angle of the cutter by means of the graduated quadrant. The method of grinding is the same as for grinding any other type of cutter.

Particular attention has been given in the design of this machine to the convenience of operation, all controlling attachments being within easy reach of the operator's working position. The construction is also very rigid as the engraving indicates, the entire grinding mechanism being carried in a heavy base casting. The saddle on which the cutter is mounted has a horizontal adjustment of 10 inches and a vertical movement of 3 inches, to accommodate any size cutter within the machine's capacity. The grinding spindle has a 5-inch stroke and also a 1½-inch adjustment at right angles to the stroke, in order to compensate for the wear of the grinding wheel. The machine can be arranged for either belt or motor drive.

DAVIS-BOURNONVILLE OXY-ACETYLENE WELDING AND CUTTING MACHINE

The hand-operated oxy-acetylene blow-pipe, the use of which in connection with the cutting and welding of metals is familiar to most mechanics, has been supplemented by a machine designed for doing certain classes of work better and more efficiently than would be possible with a hand torch. This development is known as an acetylene welding and cutting machine, and it is a recent addition to the line of autogenous welding and cutting apparatus built by the Davis-Bournonville Co., 97 West St., New York. For that class of work on which the welding or cutting is done in straight lines, the machine can be used with economical results, as it provides means for mechanically moving the torch in the desired direction. The machine is also especially adapted to repetition work and for operating on very thin sheets, because of the certainty with which it can be regulated.

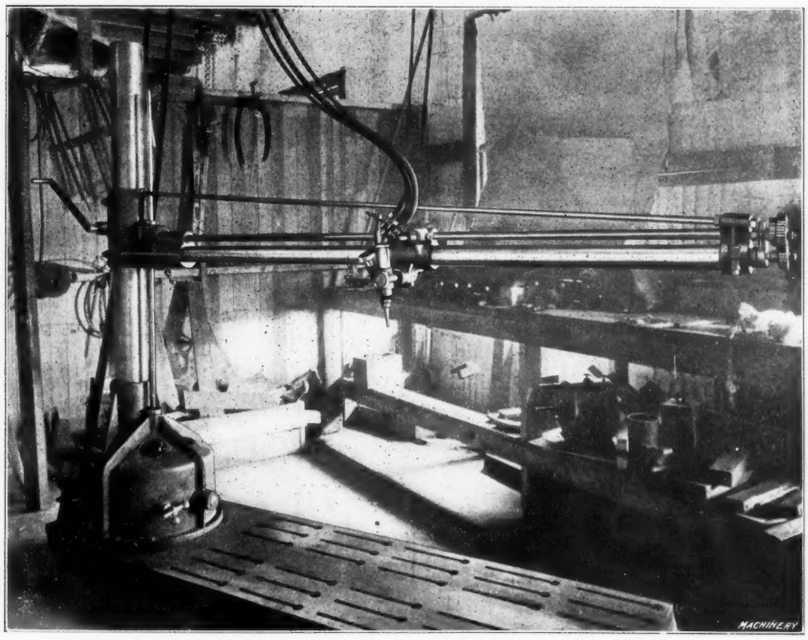


Fig. 1. Davis-Bournonville Oxy-acetylene Welding and Cutting Machine

A general view of this new welding machine is shown in Fig. 1. It consists, principally, of a cylindrical upright which carries a long hollow arm projecting 6 or 7 feet on one side. By means of a rack and pinion, this arm may be adjusted vertically on the column to any height desired. At the base of the upright, tight-and-loose pulleys are mounted on a short horizontal shaft and these are driven from an ordinary countershaft above. The horizontal shaft is connected through an adjustable friction disk drive to a vertical shaft, which, in turn, drives, through bevel gears, a shaft which passes through the hollow arm. At the outer end of the arm an arrangement of gears enables the enclosed shaft to transmit its movement to a horizontal screw mounted above the arm. The rotation of this screw, which might be called a feed-screw, operates the carriage upon which the torch and its controlling fixtures are

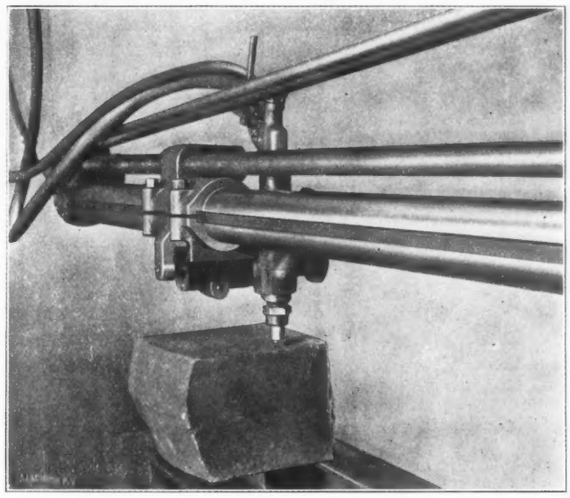


Fig. 2. Machine arranged for Heavy Cutting Operation

mounted, back and forth when welding or cutting. The oxygen and acetylene gases are supplied to the torch through the flexible tubes shown.

The tip used for welding is similar to the ordinary form, and the torch, which has an angular adjustment, is set at an angle of about 40 or 45 degrees to the horizontal, the inclination being to the rear of the welding movement. For many classes of work, the method of welding is quite simple. For example, if the weld is to be a flat one, the two pieces are simply clamped in the correct relative positions they are to occupy and the operation of welding is performed by the torch as it moves across the work at the proper rate of speed. Changes in speed may be obtained both by the adjustable friction drive in the base and also by the change gears at the end of the arm. In fact, a wide range of speeds is available, as the movement of the carriage may be varied from 3 to 24 inches per minute. The maximum travel of the carriage on the arm is 5 feet 5 inches, which means that a weld of approximately that length may be made. If an angular weld is desired, the only change to be made is in the arrangement of the work.

This machine, in addition to performing welding operations, can readily be used for cutting metals; in fact, the mechanical means of moving the torch in a straight line makes the machine especially adapted to this purpose. When metals are to be cut, the ordinary welding tip is replaced by one having three jets which are in line with the direction of movement. The torch is placed in a vertical position so that the flame is forced directly downward on the work. The first of these three flames is a heating jet of oxygen and acetylene, and at the rear there is another, but smaller, heating jet of the same kind. Between these two flames there is a cutting jet of pure oxygen, which is supplied from an independent tank because, ordinarily, the pressure back of the cutting jet is higher, and sometimes much higher, than is the case with the oxygen for the heating jet. By arranging the jets in the manner described, a strong heat is supplied just ahead of the oxygen

and a moderate one just behind. The first jet is to raise the steel being cut to the temperature of combustion; a pure oxygen flame then comes into action and the metal is "cut." It has been found, however, that by providing an auxiliary heater in the rear, the work of cutting is facilitated. The operation is probably as follows: The front jet heats the metal to a certain temperature, which is doubtless somewhat diminished by the time the pure oxygen jet comes along, for while the oxygen jet is only ⅜ inch back of the first one, no doubt there is some heat lost through conduction before the cutting jet reaches a given spot, especially if the movement is slow, as would be the case with very thick material. The rear jet, however, provides additional heat in order to reduce this dissipation of heat by conduction. When thin plates are being cut, the rear jet is not necessary and can be shut off. This machine can be used advantageously for cutting either thin or thick material. The illustration Fig. 2 shows the machine arranged for a heavy cutting operation.

For certain classes of work, pre-heating prior to the use of the machine, could doubtless be employed to advantage in connection with welding operations or, in other words, it is not necessary to do all of the heating with the oxygen and acetylene gases. The saving, however, that can be effected by pre-heating, where the form and character of the work are favorable to it, does not result alone from a reduction in the consumption of gases, as time can also be saved. For example, certain pieces of work requiring a long seam and having sheets varying from 0.10 to 0.12 inch thick, were welded on a European machine at the rate of about 12 inches per minute without pre-heating, but when the same class of work was pre-heated before welding, a speed of from 26 to 28 inches per minute is said to have resulted. The methods of pre-heating would, of course, be varied somewhat with different classes of work. For small repetition work, pre-heating might in some cases be done subsequent to clamping, but prior to putting the work on the table, whereas other parts would require pre-heating with the work in the welding position. One desirable feature of pre-heating is that it diminishes the effects of expansion and contraction, in addition to effecting an economy in the use of gas and a saving in time.

HOLDER FOR BLUEPRINTS

The blueprint holder shown in Fig. 1 is designed to keep a drawing in plain sight and eliminate the time often lost by workmen while looking for prints that are not kept in any particular place. This holder also prevents drawings from being soiled or damaged. The device is very simple and there are no springs nor clips to get out of order.

The holder proper is composed of a vertical rod *A* on which are mounted two parts *B* and *C*. The upper member *B* is free to slide on the vertical rod and its weight holds the mounted

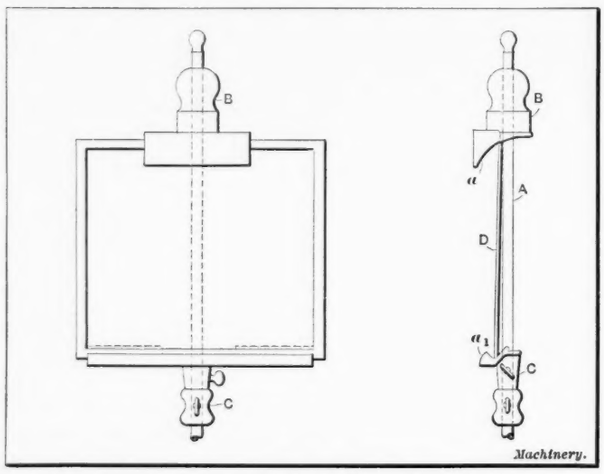


Fig. 1. Smith Blueprint Holder adapted for Holding Mounted or Unmounted Prints

print *D* in place. If the print is unmounted it is held near the upper edge between the inclined surfaces *a* and *a*, of the parts *B* and *C*. Provision is made for adjusting part *C* vertically to locate the print at the proper height. Rod *A* can be attached by a bracket to the machine or, if the holder is intended for bench use, a round base is provided. Fig. 2 shows this holder with a mounted print in place attached to a lathe.

A holder for text-books that has been devised for use in schools or laboratories, can also be applied to the same

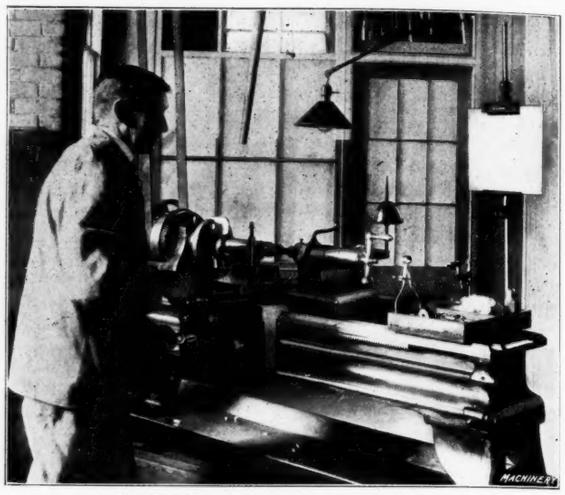
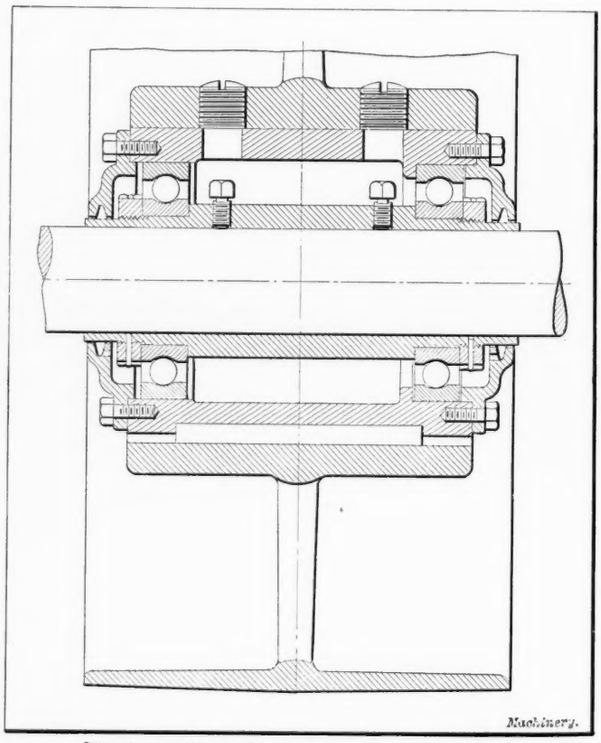


Fig. 2. Blueprint Holder applied to a Lathe

vertical rod used for the blueprint holder. Both of these holders have been put on the market by the Industrial Education Book Co., Boston, Mass.

HESS-BRIGHT INTERCHANGEABLE BALL BEARING

A form of loose-pulley mounting has been brought out by the Hess-Bright Mfg. Co., 2111 Fairmount Ave., Philadelphia, Pa., to enable pulleys of any diameter, but of approximately



Interchangeable Ball-bearing Mounting for Loose Pulleys

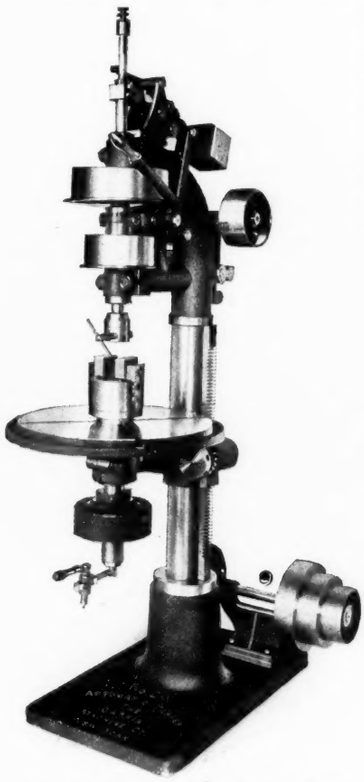
equal belt width, to be mounted interchangeably on standard hubs containing Hess-Bright ball bearings. This bearing is shown applied to a pulley in the accompanying sectional view. The inner races of the ball bearings are a light press fit on a steel sleeve, and they are clamped by the nuts and wire locking rings shown. One outer race has a slight endwise freedom between the shoulders, and the other is entirely free; both are "sucking" fits, thus permitting a slow creep

in order to distribute wear. The oil-retaining and dust-excluding closures at the end are very important. These closures have lips at least 3/32 inch wide, with sharp edges bored 1/64 inch larger than the ends of the sleeve. The inner race at each end has a return oil hole, and a single filling of oil or grease will last many months with these closures. The sleeve is secured to the shaft by set-screws, and for further convenience of access, there are corresponding holes through the pulley hub, which are closed by the screw plugs shown.

GARVIN AUTOMATIC TAPPING MACHINES

The Garvin Machine Co., Spring and Varick Sts., New York, has added two automatic tapping machines to its extensive line of tapping machinery. One of these machines, known as the No. 2, is shown herewith. This design will tap from ¼-inch to ⅞-inch holes in cast iron, and from ¼ inch to ¾ inch in steel. It will also drive ½-inch pipe taps in cast iron and ⅜-inch pipe taps in steel. The other machine is a No. 2 back-geared type, having a capacity varying from ½ inch to 1¼ inch in cast iron, and from ½ inch to 1 inch in steel. It will drive ¾-inch pipe taps in cast iron and ½-inch pipe taps in steel.

The machine shown in the illustration is equipped with a special chucking arrangement mounted on the table, consisting of a Garvin wrenchless two-jaw chuck operated by compressed air. This feature adds greatly to the productive capacity of the machine, as there is no time lost in clamping and unclamping the parts operated upon. The chuck jaws are opened instantly or closed for gripping the work by simply turning an air-valve. The work is then ready for the tap, which is started, for a couple of threads, by the hand lever shown, after which no further attention is required. When the tap reaches the bottom of the hole it is tripped and returned automatically.



Garvin Automatic Tapping Machine with Pneumatic Chuck

The spindle is fitted with two friction pulleys, driven in opposite directions by one continuous belt, and between these pulleys there is a friction clutch keyed to the spindle. This friction clutch is connected with a lever at the right, by a toggle arrangement, which is adjustable for the desired tension, so that any extra safety device to prevent the breaking of taps is unnecessary. The tap is started by the lever at the right, and is tripped and reversed automatically at any point by an adjustable screw stop on the upper end of the spindle, which strikes the tripping lever on top of the machine.

The spindle is balanced and fitted with a positive drive chuck for holding the taps. The table is surrounded by an oil groove and is adjustable up and down on the column to suit the work. This tool will operate satisfactorily at high speeds and will trip and reverse after being set, even though the operator should continue to press down on the starting lever.

GREAVES-KLUSMAN QUICK-CHANGE 15-INCH LATHE

In the November, 1910, number of MACHINERY (department of New Machinery and Tools) we illustrated a 15-inch lathe built by Greaves, Klusman & Co., Cincinnati, O. This company is now manufacturing another 15-inch size that differs somewhat from the machine previously described. One of the noteworthy features of this latest design is the new quick-change gear-box which is compact and simple in construction. This gear-box gives a change of feeds varying from 6 to 168 and a range of threads varying from 2 to 56 per inch, including 11½ pipe thread. This entire range of threads and feeds is obtained by operating the two handles shown. The one to the left controls the fine changes, and the segment handle or lever to the right compounds these changes. An index plate attached to the gear-box shows clearly the position of the two handles for any thread or feed. If it is desired to cut a special thread, this can be done by substituting change gears at the head end of the lathe.

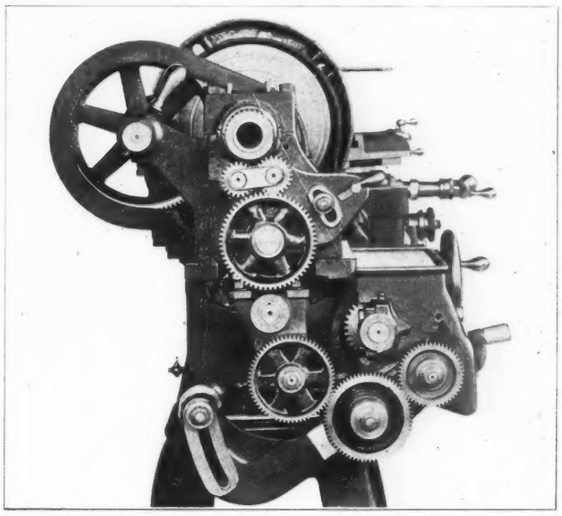


Fig. 1. End View of the Greaves-Klusman Lathe

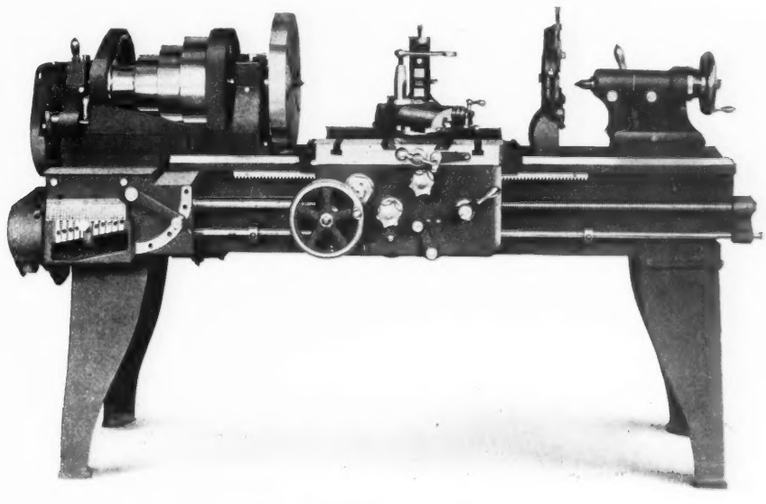


Fig. 2. Greaves, Klusman Heavy, Quick-change 15-inch Lathe

All gears are made from solid steel and the compounding gears run in an oil bath. Longitudinal feeds can be auto-

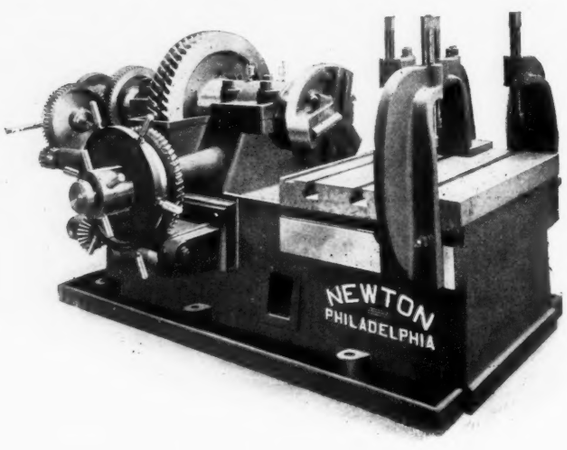
matically stopped in either direction, and the feed-rod is supported at each end of the apron, which maintains its alignment for all positions. The carriage is fitted with a chasing dial for thread cutting, which enables the thread to be "caught" at any point without reversing the lead-screw. Both countershaft pulleys are thus allowed to run forward, providing a wide range of speeds.

The headstock is webbed its entire length, and the center line of both headstock and tailstock is placed back of the center of the bed to eliminate any overhang of the tool when turning large diameters. The spindle is of high-carbon steel, accurately ground, and runs in self-oiling phosphor-bronze bearings. The tailstock spindle is one-third longer than the usual form, and telescopes through a thimble at the rear. It has a full-length bearing in the barrel at the forward limit of travel, and is gripped by two sets of double-plug clamps at both ends of the barrel. An illustration showing the construction of this clamping device appeared in connection with the previous description referred to. The tailstock permits the compound rest to be swung around to an angle of 90 degrees and there is a graduated index provided for taper work.

The carriage has a full length bearing on each vee, and a wide flat bearing inside the front vee, which gives a support directly under the tool-rest and shortens the bridge of the carriage. The apron is of the double-plate box form. The gears are cut from solid steel and run on hardened and ground studs having bearings at each end. Both longitudinal and cross feeds are operated through frictions and are reversed in the apron. An interlocking arrangement prevents the feed-rod and lead-screw from being engaged simultaneously. As the illustration shows all gearing is carefully guarded. The regular equipment includes a compound rest, large and small face-plates, steady- and follow-rests, countershaft and wrenches. The maximum swing over the bed is 16⅜ inches and over the carriage 11¼ inches. The greatest distance between the centers, with a 6-foot bed, is 36 inches. There are sixteen spindle speeds, with a two-speed countershaft, varying from 5 to 475 revolutions per minute with the countershaft operating at the specified speed. The back-gear ratio is 12¼ to 1.

NEWTON RAIL-ENDING MACHINE

The machine shown in the accompanying view is a special design intended for taking short cuts on the ends of railroad rails or girder rails for street railways, and it is particularly adapted for squaring ends from which sufficient stock cannot be removed to support a saw-blade rigidly enough to give a



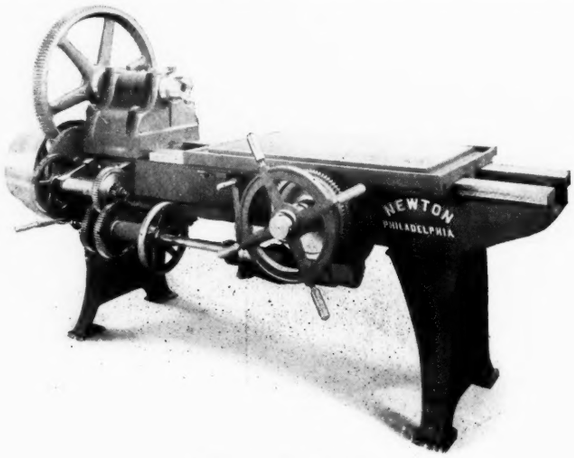
Special Machine for Squaring the Ends of Rails

square cut. This machine has a large spindle on which is mounted a head carrying three tools. This head is caused to revolve through large worm-gearing which enables heavy cuts to be taken. Feed variations are obtained by change gears, and there is a fast hand traverse to bring the cutters quickly up to the work.

The work-table is 31 inches long and 40 inches wide and has T-slots at the sides and top. There are also removable clamps for securely holding (in this case) built-up switches. The base of the machine is cored, as shown, to permit the escape of chips, and an oil pan is cast solid with it. A pump with piping and the necessary attachments is furnished for lubrication. The cutter head is 16 inches in diameter and the tools are 1¼ inch thick. The spindle is 8 inches in diameter and has an over-all bearing length of 41 inches. The bearings are bronze-bushed, and the driving worm-wheel, which is also bronze, is 33 inches in diameter. The worm is of hardened steel and is fitted with roller thrust bearings. This worm gearing is encased for continuous lubrication. The machine is driven by a 15-horsepower Westinghouse motor. The Newton Machine Tool Works, Inc., Philadelphia, Pa., is the manufacturer.

NEWTON SINGLE-SPINDLE BORING MACHINE

A machine designed particularly for boring the cylinders of air compressors, small pumps, automobile cylinders, crank and transmission cases, etc., is illustrated herewith. The drive to the spindle is by means of a large spur gear operated by



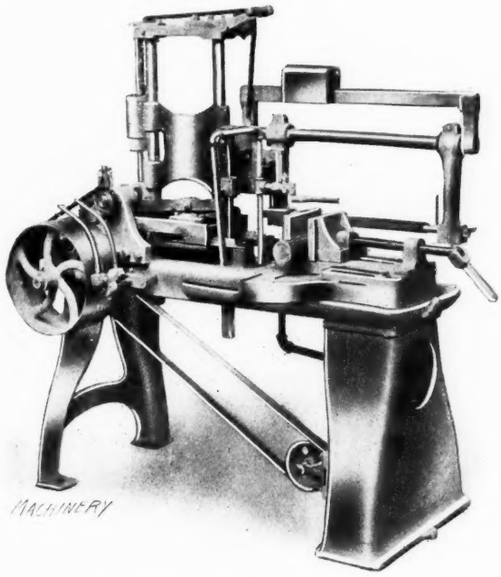
Newton Boring Machine

a three-step cone, giving three speed changes varying approximately from seventeen to thirty revolutions per minute. The work-table is fed along the bed by means of a rack and spiral gear, and it has three changes of geared feed, ranging from 0.010 to 0.050 inch per revolution of the spindle; the maximum length of the feed is 32 inches. There is an automatic release to the feed, and the table can be operated by hand. The work-table is 21 inches wide and 36 inches long over the working surface, and it is entirely surrounded by an oil channel. The work-table has square locked bearings on the base, and side adjustment can be made by means of a taper shoe. The distance from the center of the spindle to the top of the table is 8¼ inches. The spindle is 3½ inches in diameter; it has a broad driving slot and a through retaining bolt for holding the boring-bars. The hole in the spindle is a No. 11 Brown & Sharpe taper. The equipment includes a pump with piping and attachments and a countershaft. This machine is built by the Newton Machine Tool Works, Inc., Philadelphia, Pa.

STERLING NO. 2½ HACKSAW MACHINE

The Diamond Saw & Stamping Works, Buffalo, N. Y., has placed on the market a new high-speed power hacksaw machine which is known as the No. 2½. This machine is equipped with an automatic lifting device for raising the blade on the return stroke to eliminate unnecessary wear, and there is also an adjustable vise so that the full length of the saw can be used. The machine has a cutting capacity up to 7 inches for either round or square stock, and any length of blade from 10 to 15 inches, inclusive, can be used. The stroke of the saw is 6 inches. The drive is through milled gears of wide face. The bearings are large, and the gear bearings are adjustable so that lost motion can be taken up if necessary. The bearings for the main shaft are bushed, and wear can be eliminated by driving out the old bushings

and replacing them. The vise can be swiveled for cutting any angle up to 45 degrees, and it is interchangeable so that it can be removed and replaced if necessary. The vise jaws are 3⅝ inches high, 5¾ inches wide, and the maximum opening is 7 inches. The feed of the saw is by gravity, and there is an

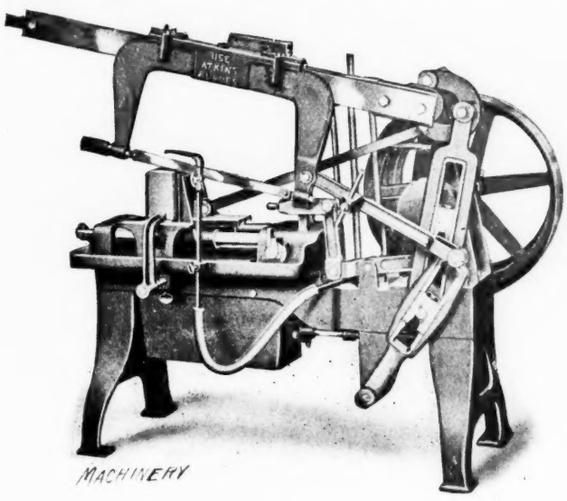


Sterling No. 2 1/2 Hacksaw Machine

automatic shut-off. The front cabinet leg forms a tank to which a pump is attached for supplying soda water or other lubricant to keep the blade cool when running at high speed. This machine is designed to operate at one hundred strokes per minute with lubrication. It weighs 380 pounds.

ATKINS NO. 7 HACKSAW MACHINE

E. C. Atkins & Co., Indianapolis, Ind., are now building an improved design of power hacksaw machine. This latest design has the automatic stroke adjustment and the quick return common to the machine previously built, and, in addition, a raising device to avoid unnecessary wear of the teeth, a two-



Atkins No. 7 Hacksaw Machine

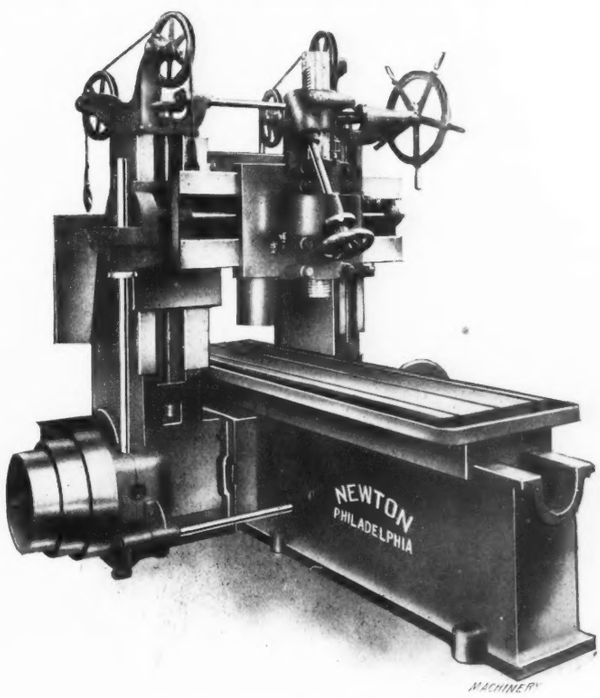
speed pulley, a depth gage and a lubricating system. The machine also operates with a draw cut, the cutting stroke being effected with a pulling instead of a pushing motion.

The reciprocating mechanism for the saw is so arranged that the stroke is automatically adjusted to the size of the material being cut, which enables the full length of the saw-blade to be used. The way this automatic adjustment is effected on this latest design is as follows: The crankpin block operates in a slotted link, which is pivoted at its lower end to another block mounted in a lower slotted link as shown. This lower link swings about a pivot and is connected at its upper end with the saw frame by a connecting arm. The rear jaw of the work vise is connected by a steel rod with the hanger which holds the upper slotted link so that the position of the rear jaw determines the position of the link. When a large piece of stock is clamped in the vise, the connection with the rear jaw causes the upper link to be raised, which decreases the stroke of the saw frame to compensate for the increase in the size of the stock, and, inversely, the stroke is automatically lengthened for small diameters. In this way the entire blade is utilized.

In order to secure the full efficiency of the machine when cutting different sizes and kinds of material, it has been equipped with a two-speed pulley which enables the speed of the saw to be changed as required. A variation of thirty strokes per minute is possible. By means of a special adjustment, the saw can be stopped automatically at any desired depth of cut. There is a complete lubricating system, so arranged that the cooling compound is returned to the tank, where it is filtered before again being used. The saw frame has a long compensating bearing which insures an accurate cut, and the machine is rigidly built throughout.

NEWTON VERTICAL SLAB MILLING MACHINE

The Newton Machine Tool Works Inc., Philadelphia, Pa., has added to its line of milling machines a design especially adapted to machining broad surfaces on light castings, such as are used in the manufacture of textile and printing-press machinery. The general construction of this miller and the



Newton Vertical Slab Milling Machine

driving mechanism is quite plainly indicated in the illustration.

The spindle, which has a diameter of 5 inches, is driven through worm-gearing connecting with the driving pulley by the horizontal and vertical shafts shown. The worm-wheel is 13 inches in diameter and both worm and wheel are encased for continual lubrication. The worm-wheel is made with a bronze ring and the worm is of hardened steel and has roller thrust bearings. The spindle is counterweighted and has 6 inches of independent vertical adjustment by the angular handwheel shown. The sleeve revolves in bronze-bushed capped bearings, and the spindle saddle has a square locked bearing on the rail. The spindle saddle has a hand adjustment only

on the cross-rail, and the latter is counterweighted and is adjusted vertically by hand.

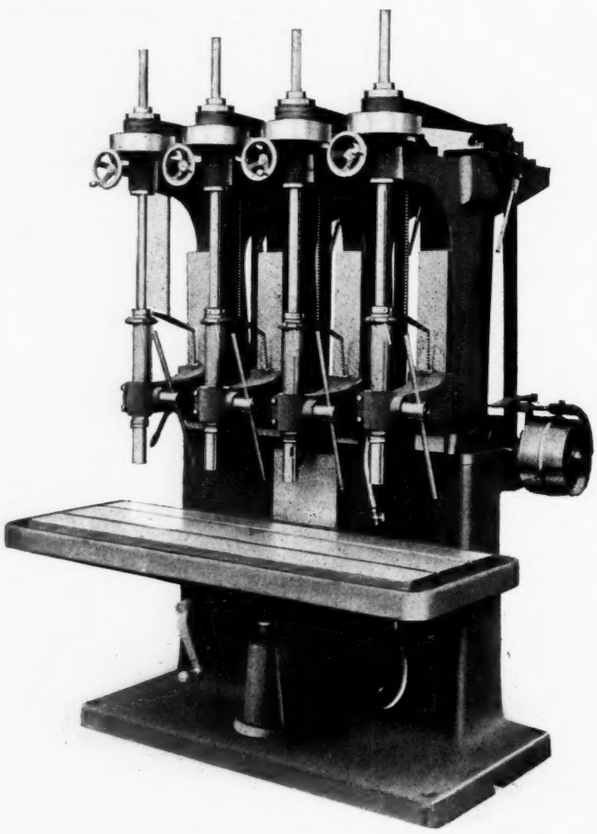
The work-table has square locked bearings on the bed, and it is driven through an angular rack and spiral gear. There are nine changes of geared feed, ranging from ½ inch to 8 inches per minute, and a power fast traverse, both of which are available in either direction, in addition to the hand adjustment. The working surface of the table is 20 inches wide and 6 feet 8 inches long, and it is surrounded by an oil channel as shown.

The distance between the uprights is 29¼ inches and work 27 inches in width can be admitted. The spindle saddle has a cross adjustment of 20 inches, and the maximum height from the end of the spindle to the surface of the work-table is 20 inches. The spindle has a No. 6 Morse taper and an external thread with a through bolt. The vertical adjustment of the spindle is measured by a micrometer gage.

This machine is of heavy construction, the design being based on the principle that weight is necessary to insure the required rigidity for producing accurate work.

HIGH-SPEED BALL-BEARING DRILL PRESS

The Cincinnati Pulley Machinery Co., Cincinnati, O., is now manufacturing the new design of No. 3 "Avey" high-speed ball-bearing drill press, which is illustrated herewith. This machine is built in either the single or multiple spindle type,



No. 3 Avey High-speed Drill Press, built by the Cincinnati Pulley Machinery Co.

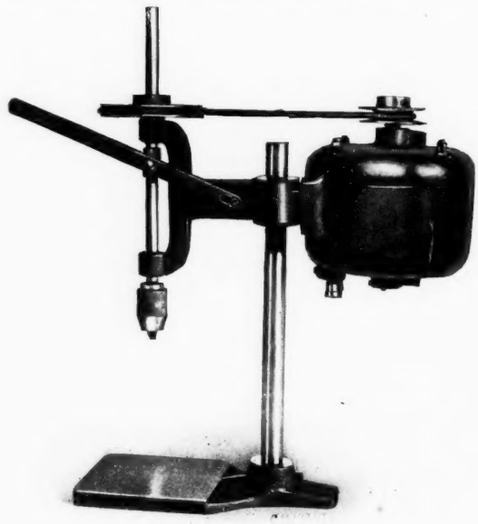
and it has a capacity for drills up to the limit of No. 3 Morse taper shanks, or for diameters up to and including 1¼ inch.

The distance from the spindle center to the column face is 12 inches, and the spindle sleeve has a feed of 8 inches without resetting the head. The spindle sleeve is graduated and has a stop collar or depth gage mounted on it so that any predetermined depth of hole can be drilled without the use of a measuring scale. Four changes of speed are available for each spindle, and the driving belts pass over an adjustable idler carriage at the rear, which enables the belt tension to be varied as required. These idler carriages are controlled from the front of the machine by the handwheels shown, and a screw feed.

The spindles are 1 3/16 inch in diameter and have a No. 3 Morse taper. The driving pulleys are arranged for a 2-inch belt. The machine can be equipped with a lubricating outfit and the lower part of the column forms the tank. The table can be supplied with T-slots or be left plain, if desired. The working surface is surrounded by a large oil channel, as shown, to catch the lubricant, which is returned to the tank through a flexible pipe. The weight of the four-spindle machine illustrated, is approximately 4000 pounds.

SMALL MOTOR-DRIVEN DRILL PRESS

The motor-driven drilling machine shown in the illustration was designed by the Willey Machine Co., Jeffersonville, Ind., to meet the demand from the hardware trade, model

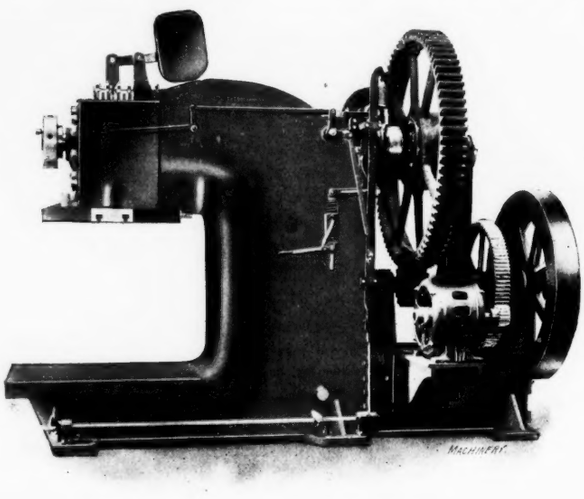


Small Motor-driven Drill Press, built by Willey Machine Co.

makers, amateurs, etc., for a light bench drill of simple design. This machine has a capacity for drilling small holes up to about ¼ inch in diameter. The maximum travel of the spindle is 3 inches, and the sliding head has a movement of 7 inches on the column. The spindle is driven at a speed of 1000 revolutions per minute, by a 1/20 horsepower motor which can be furnished for either direct or alternating current. The weight of the machine is thirty pounds, and its general construction is clearly indicated by the illustration.

LARGE COPING AND PUNCHING MACHINE

The accompanying illustration shows a large coping and multiple punching machine especially designed and built by the Queen City Punch & Shear Co., Cincinnati, O., for the pur-

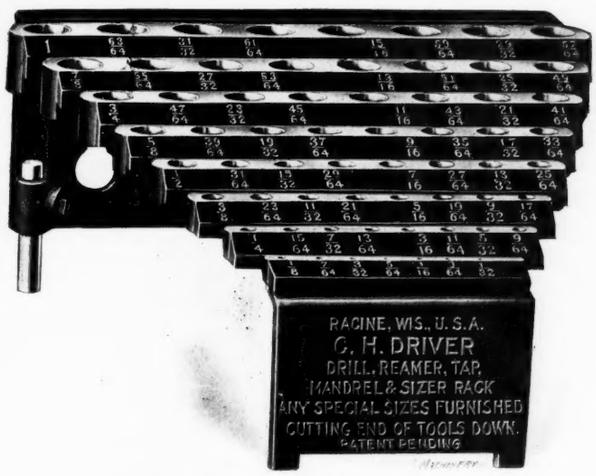


Queen City Coping and Punching Machine

pose of coping and punching sections from Bethlehem I-beams. This is said to be the first machine ever built solely for this purpose. It has a very large range beneath the ram or plunger, which is a solid steel casting, 42 inches long and 14 inches wide on its lower end. The die bed is 62 inches long from front to back and 32 inches wide, and has T-slots for fastening the various tools and appliances. The drive is by a motor attached to the side of the bed as shown. The clutches are of steel castings and of the type recently brought out by this company. This machine weighs about 63,000 pounds.

DRILL AND REAMER RACK

The rack or holder illustrated herewith is designed to keep such tools as drills, reamers, taps or mandrels in a regular place so that they will be available when wanted, and it also forms a convenient gage for determining the different sizes. The tools are held vertically in the holes shown which, in the particular rack illustrated, vary in diameter by 64ths of an inch, and when tools are being put away, they can be inserted in the rack without referring to any size marks by simply choosing the proper size hole in each case. From this it will be seen that the rack is practically a limit gage, as a tool cannot be put in a larger or smaller hole than the one representing its size, because it will not enter if too large and will drop through if too small. When a tool is taken from



Rack for Holding Drills, Reamers, Mandrels, etc.

the rack, its size is shown by the figures opposite the hole, and this size cannot be wrong, as a tool either larger or smaller could not be retained in that particular hole. The rack has been arranged in this way to eliminate calipering and the use of drill gages.

This rack is made in sections and all parts are interchangeable, so that its size can be varied to meet individual requirements and special sections can be added if necessary. While the holes in the rack illustrated vary by 64ths, they are also made in sizes varying by 32nds, 16ths or 8ths of an inch. This rack is manufactured by C. H. Driver, 1419 16th St., Racine, Wis.

BAIRD SPRING-MAKING MACHINES

Several designs of spring-making machines built by the Baird Machine Co., Oakville, Conn., are illustrated in Figs. 1 to 4, inclusive. This company has made, heretofore, special spring-making machinery for concerns manufacturing parts requiring one or two forms of springs in such large quantities that a machine specially designed for that particular form was desirable. In order to meet the demand from spring manufacturers for spring-making machines having a comparatively wide range, the standard designs illustrated herewith were brought out.

These machines are divided into three different types. Fig. 1 illustrates a coiling and cutting machine. This design can be equipped with either die or roll tools to suit the form of spring required. The die tools are more easily changed from one size to another, but their initial cost is greater, as a separate set of tools is necessary for practically each size of spring; therefore the kind of tools to use depends somewhat on the conditions. The roller tools are better for jobbing manufacturers, as the same rolls can be used with a given diameter of wire, for making any spring within the capacity of the machine, by simply making the necessary adjustment.

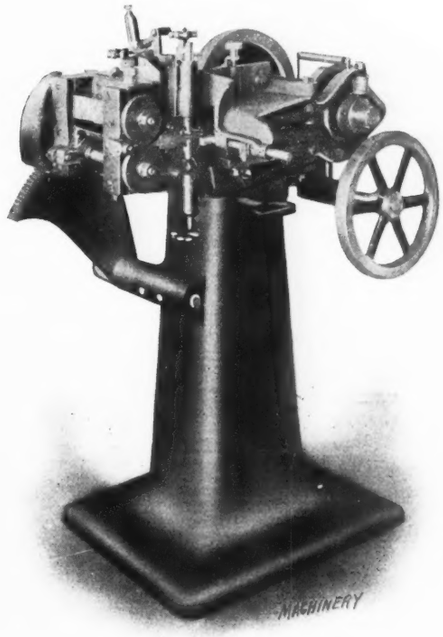


Fig. 1. Baird Spring Coiling and Cutting Machine

This type of machine automatically takes the wire from the coil, feeds it a predetermined length and coils either a right- or left-hand, open or closed spring and cuts it off. Attachments may be applied to the machine for varying the pitch or distance between the coils of the spring so that a spring of either the open or closed type can be formed. A diameter-changing attachment can also be applied for making either cone- or barrel-shaped springs, and attachments can be arranged to make cone- or barrel-shaped springs with squared

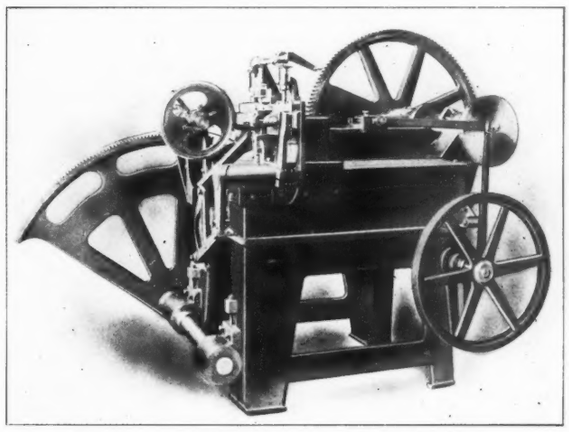


Fig. 2. Large Spring Winding and Cutting Machine

ends or other combinations of form. A setting attachment can also be applied to "set" the spring or take out the initial tension. This machine is made in sizes taking wire up to about 3/16 inch in diameter and for making springs up to about 2 inches in diameter. Each machine also has quite a wide range of adjustment.

Figs. 2 and 3 illustrate what are known as spring winding and cutting machines. The springs are formed in these machines on an entirely different principle from the coiling type. They will also make either open, closed, right- or left-hand, and

some types of cone springs, but all of these have straight projecting ends, such as are often necessary for springs that are subjected to a twisting action instead of an endwise movement. The lengths of these ends can be varied within certain limits to meet different conditions.

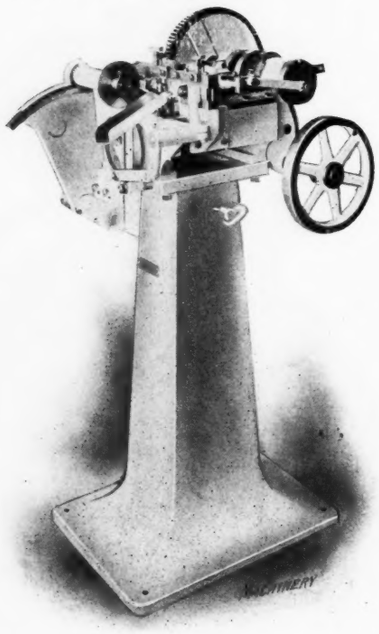


Fig 3. Winding and Cutting Type of Spring Machine

The continuous spring-coiling machine shown in Fig. 4 is similar in many respects to the spring coiling and cutting machines, except that the springs are not cut off. This type of machine is used for making long springs which contain so much wire that it is impracticable to feed to such a length.

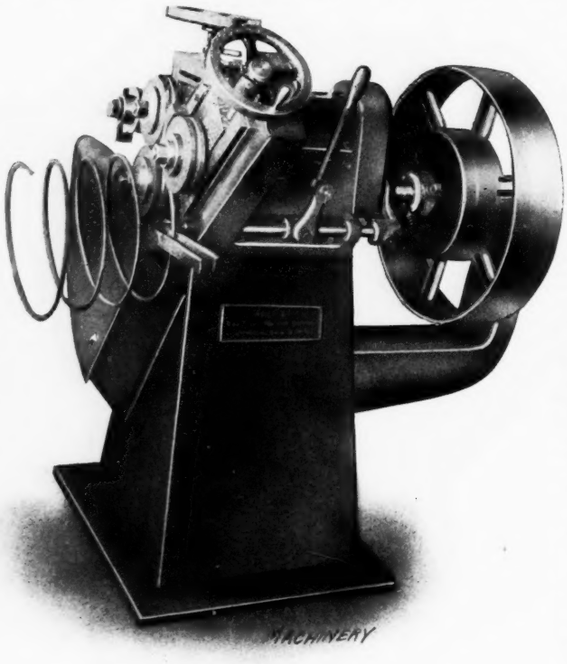


Fig. 4. Continuous Spring Coiling Machine

The attachments applied to the coiling and cutting machines for varying the pitch and diameter can also be applied to this machine so that a long length of spring, varying in pitch and diameter, for making such things as poker handles, etc., can be made and then cut into a number of shorter springs by a subsequent operation. The illustration shows the coiling machine making a spring of large diameter.

NEW MACHINERY AND TOOLS NOTES

Jig Clamp: St. Louis Sales Co., St. Louis, Mo. Quick-acting jig clamp adapted for use in connection with various types of machine tools, such as drilling machines, grinders, etc. The work is clamped by the movement of a lever.

Caster Drilling Machine: Hoefer Mfg. Co., 120 Jackson St., Freeport, Ill. Special seven-spindle machine for drilling the shaft holes in caster wheels. The machine is of the horizontal type and has a capacity for drilling from twenty to thirty castings per minute.

Keyseat Miller: Newton Machine Tool Wks., Inc., Philadelphia, Pa. Improved design of keyseat milling machine having a horizontal work-table and a vertical spindle. There is a wide range of spindle speeds and nine changes of geared feed. This machine is also adapted for milling elongated slots in piston-rods and for similar work.

Three-spindle Rail Drill: Niles-Bement Pond Co., New York. Three-spindle machine especially adapted to drilling railroad rails. The spindles are adjustable for different center distances, and they are contained in a counterweighted head having power down feed, friction release, and quick hand adjustment. The driving power is transmitted from a 15-horsepower motor at the rear, through a geared shaft.

Polishing and Buffing Machine: Hisey-Wolf Machine Co., Cincinnati, O. Portable electric polishing and buffing machine built in two sizes, having disks 6 and 12 inches in diameter, respectively, and weighing 95 and 140 pounds each. The machine is mounted on an arm having universal adjustment, and its weight is counterbalanced by a spiral spring. Pressure on the wheel is varied by a lever, and the machine can easily be swung to any desired position.

Clamp: George H. Wrigley, 447 N. 61st St., Philadelphia, Pa. Quick-acting C-clamp for structural work and general machine shop use. The adjusting screw is similar to that of an ordinary clamp except that it is provided with a lock-nut which retains it in any set position. The clamp is quickly applied or released by means of a lever which operates a lower swing jaw, the movement being through a toggle, thus giving a strong grip. The clamp is made of cast crucible steel in various sizes up to 7½ inches.

Belt Shifter: Diamond Iron Works, Minneapolis, Minn. Belt shifter for varying the speed of machine tools, consisting of a steel tube extending vertically from the machine to the countershaft. Attached to the upper end there is a short arm or loop through which the belt runs, and when a change of speed is desired the belt is shifted by turning the vertical shaft which has a lever attached to the lower end. In this way the speed can be increased or decreased quickly and the time that is often lost by the "shifting pole" method is eliminated.

Valve Grinder: R. K. LeBlond Machine Tool Co., Cincinnati, O. Special machine for grinding the angular seats on gas engine valves. The work is held close to the surface being ground by means of a draw-in attachment and collet. The chucking mechanism is free to swivel and has a micrometer adjustment which insures an accurate angular setting. The grinding head has an 8-inch wheel and there are two rates of speed. The cross-feed for the saddle has a graduated dial, and the table movement is equipped with adjustable stops.

Spline Miller: Berghausen Machine Co., Cincinnati, O. Splining machine with a capacity for cutting keyways of standard depth up to ½ inch, and with lengths up to 12 inches, in shafting varying from ½ inch to 3 inches in diameter. The two V-shaped work-holding jaws have independent adjustment so that work that is not uniform in diameter can be held. The cutter head has micrometer adjustment for depth, and the length of the cut is controlled by an automatic stop mechanism. In addition to the regular keyway cutter, there is another for Woodruff keys.

Brace Milling Machine: Newton Machine Tool Wks., Inc., Philadelphia, Pa. Brace milling machine having a capacity for milling the ends and chamfering one edge of two 8- by 8-inch angles, simultaneously. The cutter spindle is carried in a counterweighted saddle fitted to the upright with square locked bearings, and there are four changes of vertical feed, reversing and fast power traverse, and hand adjustment. The vise for holding the angles is removable, thus enabling the machine to be used for finishing the ends of columns. The machine is driven by a 10-horsepower motor.

Boring and Turning Mill: Niles-Bement Pond Co., New York. Special vertical boring and turning mill for boring and turning large gas and gasoline engine cylinders. The actual swing of the mill is 102 inches and it has a maximum height under the tool-holders of 10 feet, 6 inches. Cylinders 10 feet, 2 inches in length can be bored. The machine is equipped with a vertical boring bar, 12 inches in diameter, which has a traveling head that is raised and lowered by a feed-screw in the bar. On both sides of this central bar there are vertical boring heads for turning operations.

POINT AND RIDGE METHOD OF ELECTRIC WELDING

RESULTS OBTAINED BY UNIVERSAL WELDING CO.

The electric welding process, which from a commercial standpoint is comparatively new, has revolutionized many manufacturing methods, owing to its efficiency, particularly on that class of work which must be produced in large quantities and at a minimum cost. The extent, however, to which this method of welding metals is now employed, is no doubt very limited, in comparison with the number of manufacturing operations which could advantageously be performed by the electric process of welding. This is largely due to the fact that the art is little understood, particularly as regards the variety or range of work which can be efficiently welded electrically.

Various types of electric welding machines have been placed on the market by the Universal Electric Welding Co., 227 Borden Ave., Long Island City. One of the machines handled by this company is made to be fastened on a bench and operated by a hand lever. This same machine can be fitted to a stand and operated either by hand or by foot power, and can also be belt-driven and made to work automatically. It is particularly adapted for "electrode" welding, commonly called "spot welding." It is constructed with long projecting horns made as deep as three feet and with varying capacities to weld from the lightest gages up to ¼-inch sheets. The generally accepted idea that spot welding is practical to only as high as ⅛-inch thickness of sheet is fully disproved in the case of this machine. Pipe from 6 inches in diameter and up to 6 feet long can also be welded in machines of this type.

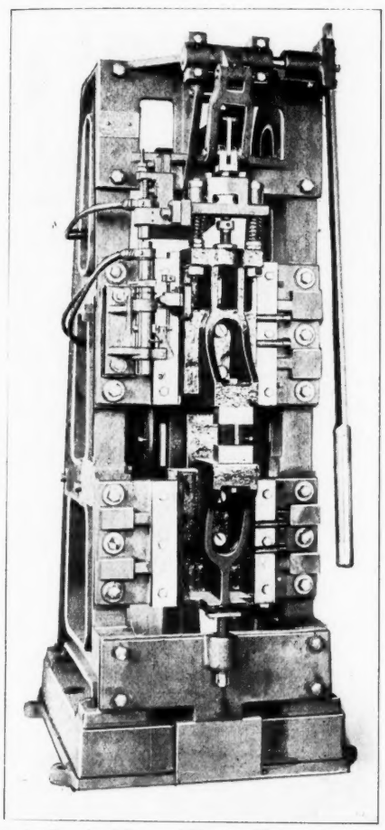


Fig. 1. Standard Type of Electric Welding Machine intended for General Work

Methods of Welding

For a number of years electric welding was confined to the butt welding of rods, tubes, etc., and later the "spot" welding of flat stock by means of isolated welds of a limited area was developed. The spot method opened up an entirely new field, which, as the result of still later improvements, has been extended until, at the present time, the electric welding method of uniting metals is adapted to a great variety of manufacturing operations. One method of making a "spot" weld is to use pointed copper dies or electrodes, which are brought into contact with the work which is welded by the passage of a large volume of low-voltage current. Another method is to raise projections above the plane surface of the parts to be welded, which serve to concentrate or localize the current in order to heat the metal to the welding point; and a still further development consists in raising ridges above the plane surfaces, which, when crossed by corresponding ridges, give the same practical results as the raised points, with the additional advantage of ease in assembling the parts prior to welding. This idea of using points or ridges in connection with electric welding has made it possible to weld, commercially, an almost unlimited variety of work, as is indicated by the accompanying illustrations which show some interesting results achieved by the Universal Electric Welding Co. In the spot electrode welding of light-gage metals, a slight indentation is usually left in the surface at the weld, but by a method developed by this company, this condition is overcome, and the sheet can be left the full thickness and finished off. By using this method there is practically no limit to

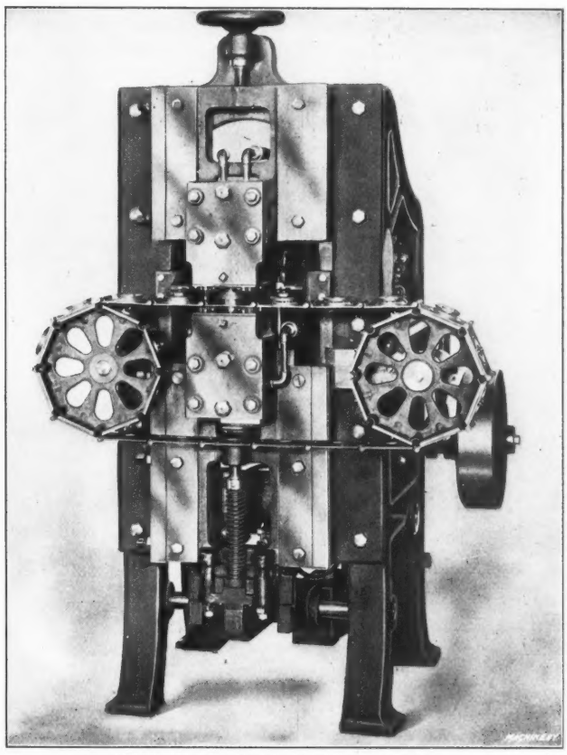


Fig. 2. Automatic Electric Sheave Welder

the thickness which can be spot welded. This is indicated in Fig. 8, where two bars each ⅞ inch thick have been spot welded together. The operation took about one minute.

Point or Projection Welding

As mentioned, the welding of sheet metal is not restricted to one spot at a time, for any reasonable number of welds can be made at one operation by the method known as "point"

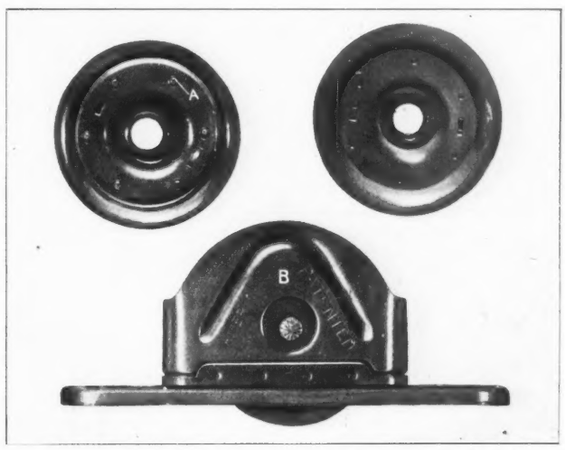


Fig. 3. Sash Pulley and Housing welded by the Point Method

or "projection" welding. In such welding, used, for example, for cooking utensils, sash pulleys, etc., the parts when stamped have small projections raised above the plane surface of the metal, the height of the projection varying according to the gage of the material. This is done during the operation of stamping. When welding such parts, properly shaped coppers are fitted to them. Each point acts as a resistance to the pas-

sage of the welding current. The current divides itself among these points and by their resistance to its passage, each becomes a heated welding point. Pressure applied to the softening metal completes all the welds simultaneously. Fig. 4 shows a spout welded to a coffee pot at twenty-three distinct points.

A marked distinction exists between the two methods of "spot" and "point" welding, as many cases occur when the spot method cannot be used, but the point method proves perfectly successful and commercial. Fig. 4 illustrates an anti-skid chain which is an excellent example. In making this chain the electrode method was just tried by the manufacturer. The point method was then applied, raising points on both the body and the strap, and resulting in a perfect weld. The output by the spot method was 600 per day of unsatisfactory welds; by the point method 3000 per day of good welds.

Another excellent example is that of the door knob shown in Fig. 4. The shank is welded to the hollow knob by six distinct points. It is impossible to weld this except by the point method.

Ridge Welding

To facilitate the assembling of parts, a further improvement was made by the introduction of so-called "ridge" welding. The result of two ridges crossing is the same as of two points, and the operation of making the weld is identically the same. Both point and ridge welding permit the use of large flat blocks of copper for electrodes, the heat being localized by the points or ridges forming the welding spot. In both these methods the coppers require very little attention except an occasional touch with a file over the surface, as against continual shaping of small pointed electrodes.

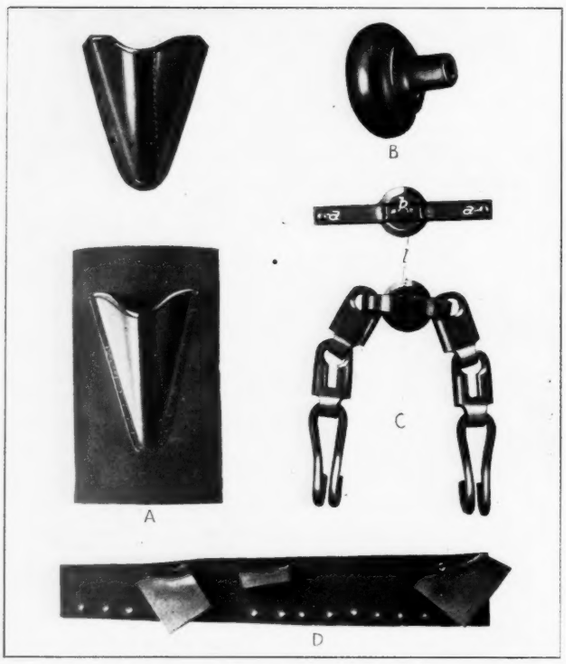


Fig. 4. Illustration of the Application of the Point Method of Electric Welding

Types of Welding Machines

The machine used for point and ridge welding is equipped with large copper electrodes instead of the pointed type, and the current is concentrated at the points to be welded by the small raised projections, as mentioned, instead of by reducing the area of the electrodes. With the large electrodes, sufficient current for welding heavy stock can be conducted without excessive heating and deterioration. A welding machine having these large electrodes is illustrated in Fig. 1, which shows a standard type intended for general work. This machine may be either hand-operated, as shown, or may be made semi-automatic, belt-driven. When a great quantity of similar articles is to be made, special machines are usually built. The automatic sheave welder shown in Fig. 2 is used by the American Pulley Co.; it welds 15,000 pulleys in ten hours.

Examples of Electric Welding

Fig. 3 shows a sash pulley and housing which is an example of point welding. The pulley is made in halves, one half having an annular ridge and the other, six projections or raised points *A*. When the points of one half are brought into contact with the ridge on the other, the electric current, being concentrated, fuses the metal instantly, and six homogeneous point or spot welds are produced. These pulleys are welded on the automatic machine shown in Fig. 2. The housing *B* is also made in two parts, each of which is joined to the base-plate by four point welds as shown.

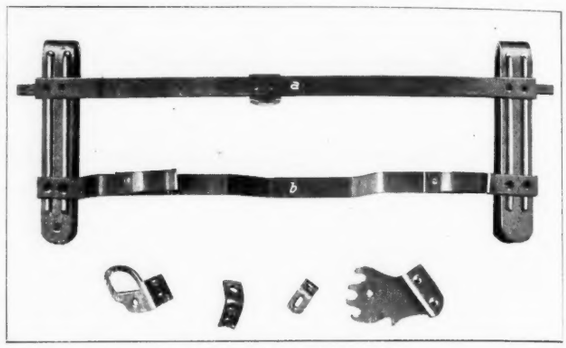


Fig. 5. Example of Ridge Welding

Another example of point welding is shown at *A* in Fig. 4, indicating how a spout is welded to a coffee pot, as already referred to. The "anti-skid" chain for automobiles shown at *C*, and also previously mentioned, has the central link *l* welded as indicated. The link is drop-forged with raised points at *a* and *b* which form the welds after the wings are bent over onto the central part. The strength of the point weld is indicated by the sample shown at *D*. An attempt to tear the small pieces from the steel strip, resulted in shearing the metal around the weld, but in no case did the weld prove defective.

Fig. 5 shows an example of ridge welding. This is part of a go-cart frame. The stock from which the end pieces are made has ridges rolled in it as shown. The cross-bar *a* is provided with two raised points at each end that come directly over the ridges, and the bar *b* has concave ends thus giving contact points where the curved edges rest on the ridges. Beneath this frame a number of small parts are shown that are prepared with projections ready for welding. The ridge method of welding is also used for welding reinforced concrete frames, the ridges which form the points of contact being originally rolled in the stock. Generally speaking, the ridge method is preferable, where practicable, owing to the greater facility in assembling parts prior to welding; the ridges also stiffen and strengthen the material. The results obtained by the ridge method are, as far as the quality of the weld is

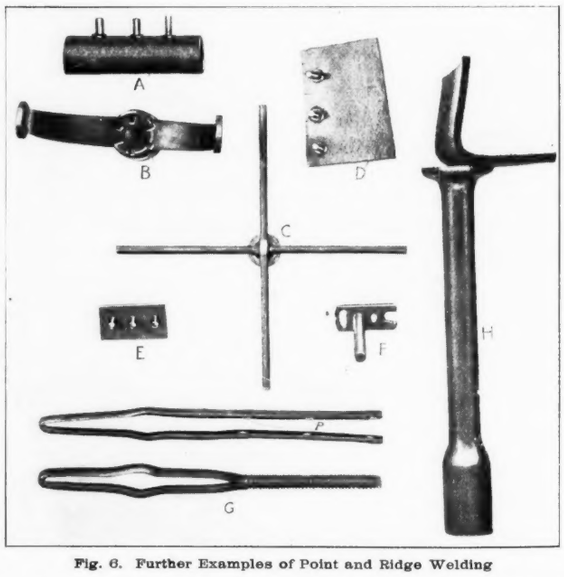


Fig. 6. Further Examples of Point and Ridge Welding

concerned, practically the same as when projections or points are used.

A number of examples including both ridge and point welding are shown in Fig. 6. A piece of tubing is shown at *A* to one side of which rivets have been welded. Part *B* is a D-top spade handle, the strap of which is welded to the cup. Six ridges are raised on the strap as shown, which make contact with an annular ridge on the cup, and the six points thus

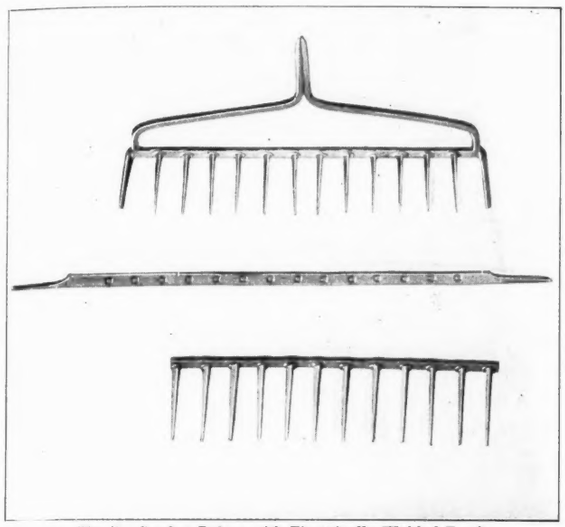


Fig. 7. Garden Rakes with Electrically Welded Teeth

formed are welded in one operation. A sample of fencing, the cross wires of which are rigidly held by an electrically welded button, is shown at *C*. The button has an annular ridge which comes in contact with each wire at two points thus forming four welds. A piece of sheet brass to which steel rivets and screws have been welded, is shown at *D* to illustrate the possibilities of uniting different metals. By the point method, it is also possible to weld copper to copper, for notwithstanding the high conductivity of copper, the use of raised points concentrates the current and fuses the metal. The plates shown at *E* and *F* have posts welded to them at right angles as shown. The ends of these posts are cupped out, so as to form a projecting center surrounded by an annular groove. This formation serves two purposes: The projecting point concentrates

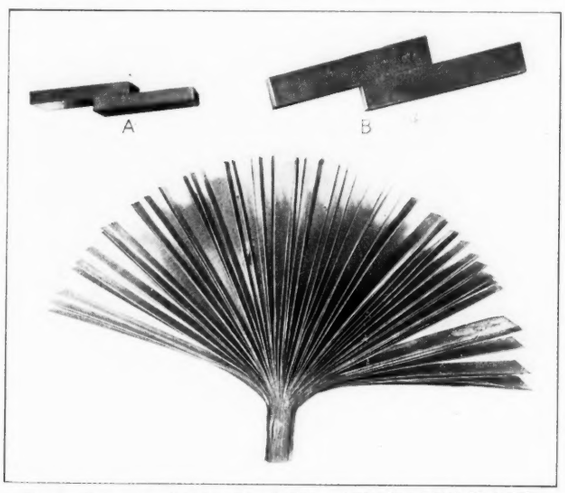


Fig. 8. Examples showing Possibilities of Welding Thick Materials

the current, and as the parts are pressed together, the metal that naturally flows outward, fills the groove instead of forming an unsightly "flash" outside the post.

A unique method of making a saw bolt for the handle of a logging saw is shown at *G*. Three projections *P* are formed on the half-round stock which is then bent over as shown in the upper view. The end which is afterward threaded is then welded at the three points simultaneously. Illustration *H* shows a method of welding a spoke to the rim of a line-shaft pulley. The end of the spoke has a projection which passes through a hole in the rim, and the latter is solidly welded to a round area in the center of the spoke.

The application of electric welding to the manufacture of garden rakes is shown in Fig. 7. The teeth of the rake in the lower view are welded to one corner of a square back. The back piece in the upper view has isolated spots formed on it (as shown in the center) to which the teeth are welded. What can be done in the welding of thick material by spot welding is illustrated by the samples in Fig. 8. Two flat pieces ⅜ inch thick are shown welded at *A*, and at *B*, two ⅞-inch square bars are welded together, this having already been referred to. The fan-shaped sample below contains 61 steel sheets of No. 26 gage that have been welded simultaneously in one minute.

The Universal Electric Welding Co. recently constructed a trolley car, 40 feet long, in four sections. The parts were all electrically welded and a saving of nearly one-half of the metal ordinarily required in the construction of such a car was thereby effected.

The various manufactured articles that have been referred to in the foregoing, are parts that are now being electrically welded on a commercial basis, and while the samples illustrated represent a very small part of what is now being accomplished, the diversified character of the work, both as to form and thickness of material, indicates to some extent, at least, the possibilities of electric welding.

* * *

LONG ADDENDUM GEARS*

The bevel driving gears in the rear axle have probably given more trouble to automobile makers and users than any other two gears used on a car. For that reason any system of gear tooth design that tends to quieter running,

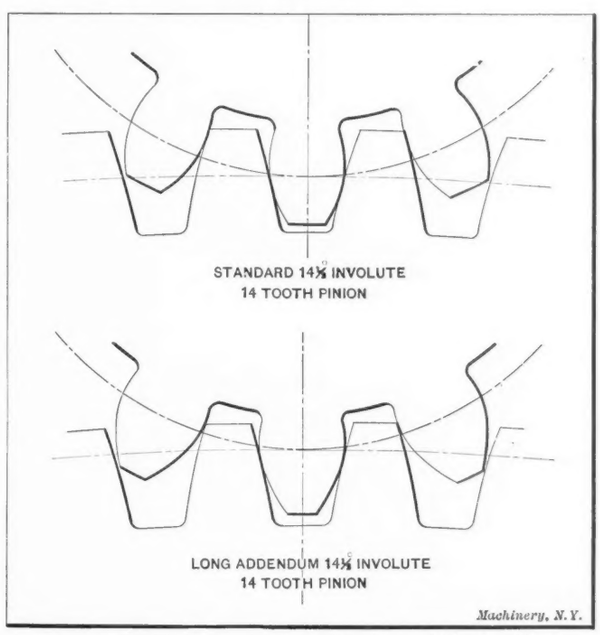


Fig. 1. Comparison between Standard and Long Addendum Gears

greater strength or durability is deserving of consideration. The system described in the following is not new, although none of the authors of standard gear books have deemed it worthy of more than a passing comment. It is, of course, understood that the tooth is of true involute or of octoid form, depending upon whether it is produced for a spur or bevel gear. The special feature of it is the lengthening of the addendum of the pinion tooth, with a corresponding shortening of the addendum of the gear tooth—the whole depth remaining the same as in the standard tooth.

With the addendum or face of the driver lengthened, the arc of approach of the gear tooth action is lessened and the arc of recess is increased—becoming all recess and no approach when the driver has only faces and the driven only flanks. This gives particularly smooth running gears—almost

* Abstract of paper by Mr. E. W. Weaver, read before the Society of Automobile Engineers, at the Dayton, Ohio, meeting, June 15-17, 1911.

equal, in fact, to spiral gears. As is well known, the friction of the arc of approach is much greater than that of the arc of recess—something on the principle of a man dragging a stick after him or pushing it ahead of him. This is very well explained in Grant's book on gearing under the heading of "The Friction of Approach."

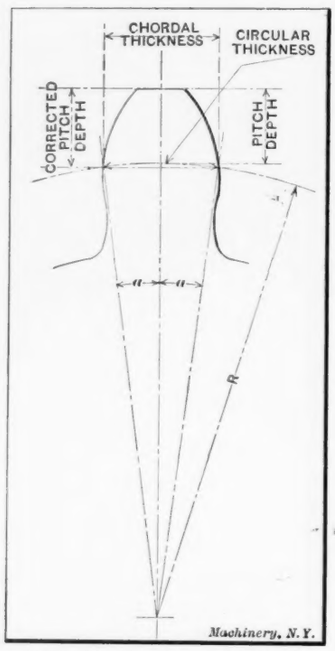


Fig. 2. Nomenclature of Gear Tooth

Pinions with Small Number of Teeth

Another advantage of this system is the very great improvement in the shape of the tooth when the pinion has a small number of teeth. It is readily seen in Fig. 1 that the pinion teeth with the long addendum are fully as strong as the gear teeth, while with the standard tooth they are not. This being the case, it is possible, in designing a rear axle drive, to select a smaller number of teeth for the pinion than one would otherwise wish to select—for instance, if the number of teeth previously used had been 17 and 54, the combination of 15 and 48 would give almost exactly the same ratio and would be fully as strong. With a 5½-inch diameter pitch circle, the outside diameter of the large gear would be decreased somewhat over an inch, thereby making the case that much smaller and lighter with all its inherent advantages.

The disadvantage of using a small number of teeth in a pinion with the standard tooth, has been the small amount of stock left between the bore of the shaft and the bottom of the tooth spaces. This is eliminated to a large extent by the decrease of the dedendum of the pinion tooth.

TABLE I. CHORDAL THICKNESS OF TEETH FOR SPUR GEARS, 1 DIAMETRAL PITCH, SPECIAL PITCH DEPTH

To obtain chordal thickness of teeth and corrected pitch depth for any diametral pitch other than 1, divide figures in table by diametral pitch required

Number of Teeth	Chordal Thickness	Corrected Pitch Depth
20 deg. Pressure Angle—For Pinions, Addendum = 0.7 Working Depth		
12	1.8545	1.4720
13	1.8554	1.4665
14	1.8567	1.4618
15–16	1.8573	1.4559
17–18	1.8584	1.4495
19–20	1.8592	1.4442
21–22	1.8597	1.4402
23–25	1.8601	1.4361
26–29	1.8606	1.4316
30–34	1.8609	1.4272
For Gears, Addendum = 0.3 Working Depth		
35–41	1.2792	0.6107
42–54	1.2793	0.6085
55–79	1.2794	0.6060
80–134	1.2795	0.6040
134	1.2795	0.6030

For bevel gears, find chordal thickness of tooth and corrected pitch depth of gear with the same number of teeth as a spur gear having a diameter equal to twice the back cone distance.

Field of Application

So much for its advantages. To look at the other side—its field of application is limited to gear sets having a large difference in the number of teeth in the gears and pinions, on account of the gear tooth becoming weaker as the number of teeth decreases. The gear having the lengthened addendum must at all times be the driver, as in reversing the application of power, the arc of recess becomes the arc of approach with its greater friction. This is of no account in the driving gears of a car, as in coasting no power is transmitted, except when there is a propeller-shaft brake.

Efficiency

One point which has not been touched on is the efficiency, and consequent life, of a gear of this system as compared with one of the ordinary or of the stub form of tooth. No exhaustive scientific tests to determine this have been made, to the author's knowledge, so it is a matter for further demonstration. For the remainder, the author is indebted to the Gleason Gear Works, of Rochester, N. Y., for supplying formulas, sketches, etc.

TABLE II. DIAMETRAL PITCH—STANDARD TEETH

Diametral Pitch	Circular Pitch	Nearest Metric Pitch or "Module"	Diametral Equivalent of "Module"	Circular Pitch Corresponding to Module
2¼	1.3962	11.0	2.309	1.3607
2½	1.2566	10.0	2.540	1.2370
2¾	1.1424	9.0	2.822	1.1133
3	1.0472	8.0	3.175	0.9896
3½	0.8976	7.0	3.628	0.8659
4	0.7854	6.0	4.233	0.7422
4½	0.6981	5.5	4.618	0.6803
5	0.6283	5.0	5.080	0.6185
5½	0.5712	4.5	5.644	0.5566
6	0.5236	4.0	6.350	0.4948

Finding Circular Thickness of Tooth

The addendum of the pinion tooth as described is arbitrarily taken as 0.7 of its working depth, and 0.3 for the gear tooth for both 14½ and 20 degrees pressure angles. To find the circular thickness of the tooth at the pitch line at these depths, multiply the circular pitch by 0.5659 for the pinion, and by 0.4341 for the gear for 14½ degree pressure angle. For 20 degree pressure angle multiply the circular pitch by 0.5927 and 0.4037, respectively for the pinion and gear.

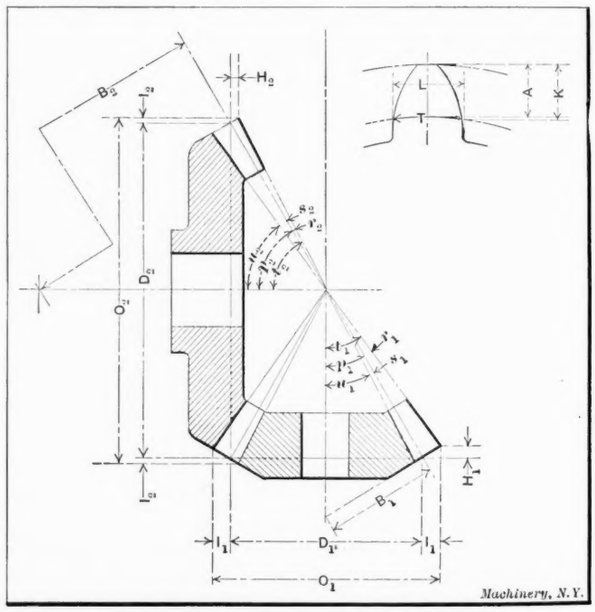


Fig. 3. Symbols used in Formulas in Table III

The impossibility of getting accurate circular measurements necessitates the calculation of the chordal thickness and corrected pitch depth. Referring to Fig. 2, let R equal the pitch radius for spur gear or the back cone distance for a bevel gear.

$$\text{Angle } a = \frac{1}{2} \times \frac{360 \text{ degrees}}{(2R \times 3.1416) \div \text{Circular Thickness}}$$

Chordal thickness $= 2 \times \sin a \times R$

Corrected pitch depth = versed sin $a \times R$ + the given pitch depth.

These values have been tabulated for gears with as large a range of tooth numbers as the system is applicable to with advantage. The formulas required have also been arranged in the logical routine order for all necessary calculations for a pair of bevel gears of this system; symbols are as indicated in Fig. 3.

As some firms are using the metric pitch or "Module" system, Table II is given for their convenience.

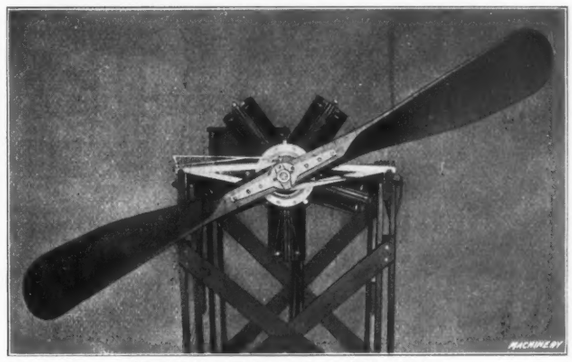
* * *

SEVENTY-TWO HORSEPOWER ADAMS-FARWELL AVIATION MOTOR

In the July, 1908, number of MACHINERY an article appeared on the Adams-Farwell aeronautic gasoline motor, describing the motors built by the Adams-Farwell Co., Dubuque, Iowa, for aviation purposes. In the January, 1911, issue, the same motor was referred to in an article entitled "Aeroplane and Airship Engines." The Adams-Farwell Co. has now brought out a 72-horsepower motor of the same type as those previously described, but revolving in a vertical plane as shown in the accompanying illustration. This motor, as described in the articles referred to, is in its principal aspects similar to the five-cylinder revolving motors used in the Adams-Farwell car, but it differs in some important features, having been designed from the ground up solely for aviation. By revolving in a vertical plane it can be direct-connected to the propeller shaft, or the propeller directly mounted on the motor shaft, as required.

The most interesting improvement found on this motor is the elimination of the carburetor and the employment of injection with a means for absolutely regulating the amount of gasoline injected into each cylinder, and insuring that all cylinders will receive exactly the same mixture. This also makes it possible to do away with the inlet valve, and employ one valve for both inlet and exhaust, as only air is drawn in by the suction stroke of the piston, while the gasoline is sprayed within the cylinder where it is mixed with the charge of air before compression. Having but one valve in the head of the cylinder, it can be made amply large to insure a full charge and a free exhaust.

In order to relieve the cam controlling the action of all five valves from the heavy load of opening a large valve against the high pressure at the time exhaust takes place, the cylinders are provided with auxiliary exhaust ports, which are uncovered by the piston on its downward stroke. No check valves are required over these auxiliary ports, as on the suction stroke, pure air, and not a mixture of gas, is drawn in, so that the air drawn in through the auxiliary ports on the suction stroke becomes a part of the explosive mixture.



Seventy-two Horsepower Aviation Motor

The control of the motor is entirely taken care of by regulating the amount of gasoline used, and the only adjustment that might be construed as belonging to the carburetting system, is the valve by means of which this control is accomplished. The speed may be regulated through quite a wide range by this simple means.

There are two spark plugs in each cylinder and two independent ignition systems, so that either set of plugs may be used, thus insuring against accidental stoppage of the motor from a broken wire. The motor has a bore of 6 inches and a stroke of the same length, and is therefore rated at 72 horsepower according to the A. L. A. M. formula. On actual propeller tests, even a greater power than this has been delivered. It will drive a 9-foot 6-inch propeller of 6-foot pitch at 900 to 1000 R. P. M., developing a thrust of from 440 to 460 pounds, which can be maintained indefinitely without overheating the motor.

* * *

CHROME-VANADIUM FORGINGS

In making chrome-vanadium steel forgings, the Erie Forge Co., of Erie, Pa., uses a steel having the following analysis:

Silicon, 0.131 per cent; sulphur, 0.017 per cent; phosphorus, 0.015 per cent; manganese, 0.60 per cent; carbon, 0.32 per cent; chromium, 0.87 per cent; vanadium, 0.18 per cent.

In the annealed state a steel of this composition shows a tensile strength of 134,000 pounds per square inch, with an elastic limit of 97,000 pounds per square inch. The elongation in 2 inches is 21.1 per cent, and the reduction in area, 57.3 per cent. After having been properly heat treated, quenched in oil, and annealed, the steel possesses an ultimate strength of 210,000 pounds per square inch; an elastic limit of 191,500 pounds per square inch; an elongation in 2 inches of 12 per cent, and a reduction in area of 45 per cent. A forging of a connecting-rod made from this steel was twisted through an angle of 270 degrees, giving it the appearance of a corkscrew, but showed no fracture or flaw of any kind.

* * *

The rapid industrial development of Canada is indicated by the fact that from January 1 to April 1, 1911, the amount of English capital invested in Canada aggregated $70,000,000.

TABLE III. FORMULAS FOR LONG ADDENDUM BEVEL GEARS

Name	Symbol		Formula	
	Pinion	Gear	Pinion	Gear
Number of Teeth	N_1	N_2	$N_1 = P_d \times D_1$	$N_2 = P_d \times D_2$
Diametral Pitch	P_d	P_d	$P_d = \frac{N_1}{D_1} = \frac{N_2}{D_2}$	$P_d = \frac{N_1}{D_1} = \frac{N_2}{D_2}$
Circular Pitch	P_c	P_c	Table II	Table II
Pitch Diameter in Inches	D_1	D_2	$D_1 = \frac{N_1}{P_d}$	$D_2 = \frac{N_2}{P_d}$
Pitch Angle	p_1	p_2	$\tan p_1 = \frac{N_1}{N_2}$	$\tan p_2 = \frac{N_2}{N_1}$
Working Depth	W	W	$\frac{2}{P_d}$	$\frac{2}{P_d}$
Addendum	A_1	A_2	$A_1 = 0.7 \times W$	$A_2 = 0.3 \times W$
Dedendum	E_1	E_2	$E_1 = A_2 + G$	$E_2 = A_1 + G$
Clearance	G	G	$G = P_c \times 0.05$	$G = P_c \times 0.05$
Full Depth	F	F	$F = W + G$	$F = W + G$
One-half Diameter Increment	I_1	I_2	$I_1 = A_1 \times \cos p_1$	$I_2 = A_2 \times \cos p_2$
Outside Diameter	O_1	O_2	$O_1 = D_1 + 2\,I_1$	$O_2 = D_2 + 2\,I_2$
Circular Thickness	T_1	T_2	$T_1 = P_c \times 0.5927 \frac{D_1}{}$	$T_2 = P_c - T_1$
Pitch Cone Distance	C	C	$C = \frac{D_1}{2 \times \sin p_1}$	$C = \frac{D_1}{2 \times \sin p_1}$
Back Cone Distance	B_1	B_2	$B_1 = C \times \tan p_1$	$B_2 = C \times \tan p_2$
Addendum Angle	r_1	r_2	$\tan r_1 = \frac{A_1}{C}$	$\tan r_2 = \frac{A_2}{C}$
Dedendum Angle	s_1	s_2	$\tan s_1 = \frac{E_1}{C}$	$\tan s_2 = \frac{E_2}{C}$
Face Angle	t_1	t_2	$t_1 = p_1 + r_1$	$t_2 = p_2 + r_2$
Cutting Angle	r_1	r_2	$r_1 = p_1 - s_1$	$r_2 = p_2 - s_2$
Distance from Crown to Pitch Line	H_1	H_2	$H_1 = A_1 \times \sin p_1$	$H_2 = A_2 \times \sin p_2$
No. Teeth in Spur Gear having Diameter equal to twice the Back Cone Distance.	S_1	S_2	$S_1 = 2 \times P_d \times B_1$	$S_2 = 2 \times P_d \times B_2$
Chordal Thickness	L_1	L_2	Table I	Table I
Corrected Pitch Depth	K_1	K_2	Table I	Table I

PERSONALS

Irving H. Page has resigned as president of the Stevens-Duryea Co., Chicopee Falls, Mass., but continues as treasurer and chairman of the board of directors.

O. C. Thompson, works manager of the National Wire Bound Box Co., South Bend Ind., has been made mechanical engineer with the Healy Box Corporation, New York.

George M. Hendee, president and manager of the Hendee Mfg. Co., Springfield, Mass., manufacturer of the Indian motorcycle, is on a business trip to Europe in the interest of his company.

D. W. Patten, for the past five years with Schuchardt & Schutte, New York, resigned July 1, and is now connected with Marshall & Huschart Machinery Co., Chicago, Ill., in the sales department.

Tracy W. Guthrie has been appointed secretary and general manager of the Standard Welding Co., Cleveland, Ohio, succeeding the late William S. Gorton who was killed by a railroad train April 17.

Col. Frank E. Cutting, for many years associated with the Hill Clarke & Co., Inc. interests has been elected president and general manager of the Lapointe Machine Tool Co., Hudson, Mass. The company was recently reorganized.

Ralph R. Lapointe has become the broach expert of the Lapointe Machine Tool Co., Hudson, Mass. This change came about through the reorganization of the company. Mr. Lapointe will also have charge of the reamer department.

Walter H. Whiteside has been elected president of the Stevens-Duryea Co., Chicopee Falls, Mass., to fill the vacancy caused by the resignation of Mr. Irving H. Page. Mr. Whiteside recently resigned the presidency of the Allis-Chalmers Co., and is an experienced manufacturer and organizer.

Harry P. Davis was elected vice-president of the Westinghouse Electric & Mfg. Co., Pittsburg, Pa. Mr. Davis has been in the employ of the Westinghouse Co. for twenty years. During the last few years he has been assistant to the first vice-president, and manager of engineering at the East Pittsburg Works.

Edwin M. Herr was elected president of the Westinghouse Electric & Mfg. Co., Pittsburg, Pa., at the meeting of the board of directors held in New York City, August 1. Mr. Herr has been first vice-president of the company since 1905. He succeeds Mr. Edwin F. Atkins who has been president of the company since June, 1910, and who declined re-election.

Ashley P. Peck, who for the past six years has been employed by the Allis-Chalmers Co., Milwaukee, Wis., as sales engineer, has recently been engaged by the Terry Steam Turbine Co., as district sales manager for the Middle West, with offices at 814 Peoples Gas Bldg., Chicago, Ill. Before engaging with the Allis-Chalmers Co., Mr. Peck was connected with the National Electric Co.

Malcolm R. Meldrum, formerly employed with the Baker Iron Works, Los Angeles, Cal., has been appointed chief engineer of the firm of W. D. Beath & Son, Ltd., Toronto, Canada. This company is re-designing its line of overhead cranes, and Mr. Meldrum's experience with Herbert Morris & Baskert, Ltd., the largest builders of cranes in England, makes him especially qualified for this work.

Information is wanted of the whereabouts of Albert Bettesworth, 418 Summerville Ave., Philadelphia, Pa., who has been missing since June 2. Mr. Bettesworth was employed in the armor shop of the Midvale Steel Works in Philadelphia, but left the city on account of irregularity of work there. Any information regarding him will be thankfully received by his cousin, Herbert Norton, at the above address.

Calvert Townley has been appointed assistant to the president of the Westinghouse Electric & Mfg. Co. Mr. Townley has for many years been connected with this company, first in Pittsburg and later as manager of the Boston office, and as special representative in New York City. For the past five years he has been closely identified with the electrification of the New York, New Haven & Hartford Railroad.

F. B. De Gress, who for the past ten years has been the New York district manager of the Crocker-Wheeler Co., Ampere, N. J., has resigned from this position and will become general sales manager of the Pulsometer Co., 17 Battery Place, New York. Besides looking after the commercial end of the business, Mr. De Gress will carry on a series of experiments with a view to improving certain features of the pulsometer in order to make it more suitable for general pumping work in power plants, industrial establishments, etc.

* * *

OBITUARIES

Edson J. Coon, master mechanic for the Waterbury Mfg. Co., Waterbury, Conn., died July 22 at Peale's Island, Portland, Me., at an age of sixty-two years. Mr. Coon was born in England, but lived in Waterbury the greater part of his life and for the last thirty years was in the employ of the Waterbury Mfg. Co.

Capt. Albert Gallatin Cummings, widely known in connection with steel works construction in Pennsylvania, and an inventor of switch and aeroplane devices, died at his home at Millersburg, Pa., July 31. Capt. Cummings, was born in New Hampshire in 1842 and served in the Fifth New Hampshire Regiment in the civil war.

Charles A. Palmer died at Pittsfield, Mass., on July 4, aged sixty-five years. Mr. Palmer was for many years in charge of the erecting at the E. D. Jones & Sons Machine Co., Pittsfield, Mass., builder of paper making machinery. Mr. Palmer's occupation took him, in the interest of the firm by whom he was employed, to all parts of the world where paper is manufactured.

G. W. S. Tham, president of the well-known Huskvarna Works in Sweden, died in Huskvarna, August 3. He was one of the most prominent men in the industries of his country, and it was largely through his efforts that the products of the Huskvarna Works—small arms, sewing machines, bicycles, etc.—became favorably known far beyond the boundaries of Sweden. He was born in 1839, and had been connected with the works mentioned since 1876.

* * *

TRAINING IN EFFICIENCY

Although scientific management has become almost a fad, the present industrial watchword of this country is efficiency, and men of notable ability are devoting their lives to devising ways and methods for increasing the efficiency of industrial workers.

In connection with this subject the investigation of Mr. Morris L. Cooke, published by the Carnegie Foundation for the advancement of teaching, and relating to the conditions of the universities and engineering schools of this country, becomes of special interest. Mr. Cooke points out that in a typical technical school the terms include only 223 working days; but of these, not less than 51 days are taken up by holidays and vacations; therefore only 172 days in the year remain for actual work in such institutions, which is but 77 per cent of the available working time during the school year, and 55 per cent of the calendar year. That the institutions which are training young men to be leaders in a field where efficiency is of the highest importance, are themselves conducted with such notorious inefficiency that nearly one-half of their working time is wasted, is certainly a most remarkable condition and one which the agitation for efficiency should remedy. It is probable that some of the dissatisfaction on the part of manufacturers with inexperienced college graduates is due to the habits of inefficiency acquired in the institutions where they were educated. If our educators are anxious to have the young engineers whom they are turning out received with greater appreciation, one of the first reforms they should institute is to inculcate habits of efficiency, responsibility and appreciation of the necessity of using every available moment to the best advantage.

* * *

In consequence of the success that has attended the use of heating value specifications in buying and selling coal, similar specifications have been issued by the Bureau of Mines to govern the purchase of fuel-oils and refined products of petroleum. A copy of these specifications can be obtained by addressing the director of the Bureau of Mines, Washington D. C.

* * *

The article entitled "Gas Engine Piston Rings," in another part of this number, should read instead, "Gas Engine Wrist-pins."

* * *

COMING EVENTS

September 1-3.—First annual meeting of the Institute of Operating Engineers held at the Engineering Societies Building, 29 West 39th St., New York.

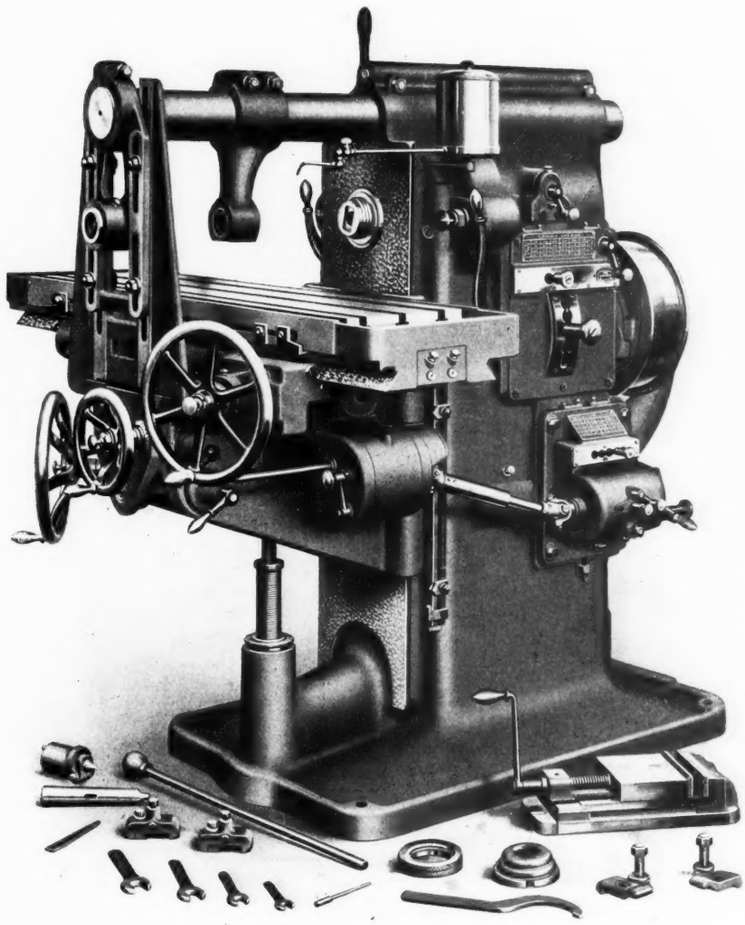
September 11-17.—International Exposition of Inventions, held at St. Louis at the new Coliseum building. For further information apply to F. W. Payne, secretary and manager of the St. Louis Coliseum Co., St. Louis, Mo.

September 27-30.—Semi-annual meeting of the National Association of Cotton Manufacturers held at the Equinox House, Manchester, Vt. C. J. H. Woodbury, secretary and treasurer, P. O. Box 3672, Boston, Mass.

October 2-3.—Autumn meeting of the Iron & Steel Institute at Turin, Italy. G. C. Lloyd, secretary, 28 Victoria St., London, S. W., England.

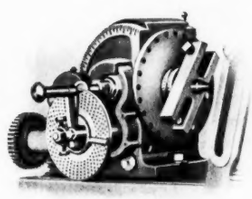
October 2-28.—Industrial and educational exposition under the auspices of the Boston Chamber of Commerce, held in the Mechanics' Building at Boston, Mass. This exposition is devoted strictly to New England industries. No manufacturer outside of New England will be allowed to exhibit.

October 9-13.—Convention of the American Electric Railway Asso-



CUT SPIRALS ON YOUR PLAIN MILLING MACHINES

We are now building our Plain Milling Machines so that the Spiral Head can be applied. Using a Milling Attachment, spirals of all kinds can be cut, a process which formerly could only be done on universal machines. This is an advantage readily appreciated by manufacturers the bulk of whose work, ordinarily, would not call for the use of a universal machine.



Write us for further particulars.

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.

ciation, Young's New Pier, Atlantic City, N. J. H. C. Donecker, secretary-treasurer, 29 West 39th St., New York.

October 10.—MACHINERY'S ninth annual entertainment, Hotel Astor, New York, Tuesday evening at 8 o'clock.

October 10-12.—Tenth annual convention of the National Machine Tool Builders' Association, in New York City. Charles E. Hildreth, 134 Gold St., Worcester, Mass., secretary.

November 2-4.—Annual meeting of the International Society for the Promotion of Industrial Education. Cincinnati, Ohio. R. T. Davis, secretary, 18 W. 44th St., New York City.

SOCIETIES AND COLLEGES

UNIVERSITY OF UTAH, Salt Lake City, Utah. Catalogue 1911-1912.

UPPER IOWA UNIVERSITY, Fayette, Ia. Catalogue 1910-1911; announcements 1911-1912.

ROSE POLYTECHNIC INSTITUTE, Terre Haute, Ind. Catalogue 1910-1911; calendar 1911-1912.

UNIVERSITY OF NEW MEXICO, Albuquerque, N. M. Catalogue 1910-1911; announcements 1911-1912.

MICHIGAN COLLEGE OF MINES, Houghton, Mich. Year Book 1910-1911; announcements, 1911-1912. Book of graduates of the Michigan College of Mines up to and including 1909. Book of views of the Michigan College of Mines.

PRATT INSTITUTE, Brooklyn, N. Y. Catalogue 1911-1912 containing an outline of the course of study in the institute, the entrance examinations and requirements, and some general information which is likely to be of value to prospective students.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Boston, Mass., announces that the proceedings of the Congress of Technology, held in Boston April 10-11, will be published. The single volume of about 500 pages, which will be sold at a moderate price, will contain the seventy-odd technical papers, relating to many fields of industry, which were read at the celebration of the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

NEW BOOKS AND PAMPHLETS

AMERICAN CEMENT DIRECTORY, WITH BUYERS' INDEX. 104 pages, 3 by 5 inches. Published by the Technical Press, Ford Bldg., Detroit, Mich. Price $1.00.

THE SOIL SOLUTION—THE NUTRIENT MEDIUM FOR PLANT GROWTH. By Frank K. Cameron. 136 pages, 6 by 9 inches. Published by the Chemical Publishing Co., Easton, Pa. Price $1.25.

THE REVOLUTION IN FREIGHT CLAIMS. Bulletin No. 8 issued by the Railway Business Association. 30 pages, 6¾ by 10 inches. Published by the Railway Business Association, 2 Rector St., New York.

THE STRENGTH OF FLAT PLATES. By Tandy A. Bryson. 15 pages, 6 by 9 inches. Published by the Department of Mechanical Engineering, Russell Sage Laboratory, Rensselaer Polytechnic Institute, Troy, N. Y.

THE CONFLICT BETWEEN FEDERAL AND STATE REGULATION OF THE RAILWAYS. Bulletin No. 15 of the Bureau of Railway Economics. 13 pages, 6 by 9 inches. Published by the Bureau of Railway Economics, Washington, D. C.

REPORT TO THE LEGISLATURE OF THE STATE OF NEW YORK BY THE COMMISSION APPOINTED TO INQUIRE INTO THE QUESTION OF EMPLOYERS' LIABILITY: Second Report—Causes and Prevention of Industrial Accidents; Third Report—Unemployment and Lack of Farm Labor; Fourth Report—Recommendation for a Constitutional Amendment.

RAILWAY SHOP KINKS. By Roy V. Wright. 290 pages, 9 by 12 inches. Published by the *Railway Age Gazette*, New York. Price $2.00.

The kinks contained in this book have been selected from the shop kinks published from time to time in the *Railway Age Gazette*. They have been classified, as far as possible, according to the different shops or departments in which they are used and are listed under the following heads: Machine Shop Kinks; Erecting Shop Kinks; Boiler Shop Kinks; Oxy-acetylene Welding and Cutting; Blacksmith Shop Kinks; Brass Foundry Kinks; Tin and Copper Shop Kinks; Engine House Kinks; Car Department Kinks; Steel Freight Car Kinks; Passenger Car Kinks; Planing Mill Kinks; Air-brake Kinks; Oil-house Kinks; Paint Shop Kinks, and Miscellaneous Kinks.

A MANUAL OF ENGINEERING DRAWING. By Thomas E. French. 289 pages, 6 by 9 inches. Published by McGraw-Hill Book Co., New York. Price $2.00.

The author of this book, who is a professor of engineering drawing at the Ohio State University, has endeavored in the preparation of the volume to conform to modern engineering practice, and to present a book which would be of permanent value in the student's library. The book touches upon all the important phases of engineering drawing and comprises chapters on: the selection and use of instruments; applied geometry; lettering; orthographic projection; developed surfaces and intersections; working drawings; technical sketching; the elements of architectural drawing; and map and topographical drawing. The book is profusely illustrated, there being 452 illustrations in the text.

HOMMES ET CHOSES DU P. L. M. 160 pages, 5½ by 8½ inches. Illustrated. Published by the Paris to Lyons and the Mediterranean Railway, Paris, France.

This interesting and instructive book, as the title implies, deals with the personnel and equipment of the Paris to Lyons and the Mediterranean Railway. It is a handsome book, beautifully illustrated with expensive engravings. Primarily, it is a history of the development of the company from its inception, leading on down to the present time. A description is given of the present rolling stock and personnel, and besides, a tour of the road, well illustrated, gives one a good impression of that portion of France traversed by the road. The book is enlivened throughout with caricatures depicting humorous incidents, past and present, on the road. The book shows careful preparation and is an exceptionally high-grade production.

MACHINE SHOP PRACTICE. By William J. Kaup. 227 pages, 5¼ by 8¼ inches. Published by John Wiley & Sons, New York. Price $1.25.

In this book the author, who was formerly head of the department of machine construction at the Pratt Institute, and who is now connected with the Westinghouse Electric & Mfg. Co., Pittsburg, Pa., presents an elementary treatise on machine shop work, prepared especially for trade, industrial and technical schools, but also for young men directly engaged in practical machine shop work. It has not been the purpose of the author to present in this volume a comprehensive treatise on machine shop practice, but primarily to deal with those things, as stated in the preface, "which seemed too small to notice by those who have already written so ably on the subject." The book contains chapters on vise work, filing, scraping, hand tools, materials of construction, drill presses, planers and shapers, lathe practice, cutting tools, boring mills, milling machines, measuring instruments, gearing, grinding, tool steel and its treatment, toolmaking and shop systems.

COST KEEPING AND SCIENTIFIC MANAGEMENT. By Holden A. Evans. 252 pages, 6 by 9 inches. 44 illustrations. Published by the McGraw-Hill Book Co., New York. Price $3.00.

The need of accurate systems of keeping costs would appear to be so obvious that every manufacturing concern should provide the best means available for the purpose; but unfortunately many concerns, some of them large and apparently prosperous, have no accurate means of determining detailed costs. The result is that while a line of manufacture as a whole may show a fair profit, large losses may be incurred in the manufacture of certain parts that have not been properly costed. The work is written particularly to fit the needs of jobbing shops and small manufacturing plants where accurate cost keeping and the principles of good management have received but little attention, and is largely based on the principles of management advocated by Mr. Fred W. Taylor. The contents by chapter headings are as follows: The Importance of Accurate Costs; The Purposes of a Cost System; The Various Elements of Cost; Distribution of Indirect Costs; Production, Order, Shop Order and Cost Section Records; Indirect Charges; Supervision of the Expense Accounts; Methods Followed in the Payment of Labor; Management; Wasted Time Detected by Time Studies; The Principles of Scientific Management which can be followed By a Manager; Methods which lead towards Scientific Management; Machine Shop Methods; Organization of a Smith Shop, A Wood-Working Shop, and a Canvas and Flag Shop; and Reductions in Cost Due to Scientific Methods.

CENTRIFUGAL PUMPS: THEIR DESIGN AND CONSTRUCTION. By Louis C. Loewenstein and Clarence P. Crissey, 435 pages, 6½ by 9½ inches, 317 illustrations. Published by D. Van Nostrand Co., New York. Price, $4.50.

The American engineering public has so long looked to the old world for guidance in the matter of centrifugal pump design, that it has been with difficulty that the ties seemingly formed by necessity have been largely thrown off. At present, however, much of the centrifugal pump business is supplied right here in America, the new designs being based on the manufacturer's own experience and data, in contradistinction to the past, when the construction, if carried on in this country, was from European designs or information. As indicative of the ability of this country to handle its own centrifugal pump design, several books have appeared written by authorities, one of the best of which is the book under discussion. One can readily appreciate the difficulties to be encountered in preparing a treatise on such a subject, involving, as it does, so much mathematics in its theory, but this particular point seems to have been well taken care of, the mathematical consideration being materially simplified by the extensive use of simple velocity diagrams and of the graphic means of representing conditions. In addition to considering the theory and design, the book contains a large number of examples of typical installations of the best-known types, and discussion of their qualifications and adaptability to the various conditions under which they are designed to operate. The extensive use of illustrations makes the book of more than ordinary interest to the average reader. There are in all seven chapters: Theory of Centrifugal Pumps; Consumption of Power and Efficiency; The Regulation and Classification of Centrifugal Pumps; The Calculation of Impeller and Guide Vanes; Design of Important Pump Parts; Types of Centrifugal Pumps; and Testing of Centrifugal Pumps.

CATALOGUES AND CIRCULARS

SKINNER CHUCK CO., New Britain, Conn. Circular illustrating and describing the Hopkinson drill vise and the No. 0 toolmakers' vise made by the company.

SCHUCHARDT & SCHUTTE, Cedar and West Sts., New York. Circular of the "Columbia" high-speed universal chucks, which were illustrated and described in the August number of MACHINERY.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletin No. 4855 illustrating and describing gas-electric motor cars of the double truck type built by the company for regular railway service.

CLEVELAND PLANER WORKS, 3148-3160 Superior Ave., Cleveland, Ohio. Bulletin illustrating and describing the Cleveland open-side planers, and calling attention to the advantages of this type of planer.

MODERN SYSTEMS CORRESPONDENCE SCHOOL, 6 Beacon St., Boston, Mass. Circular describing the methods pursued by the Modern Systems Correspondence School of Boston, of which Oscar E. Perrigo is the director.

WARREN WEBSTER & CO., Camden, N. J. Pamphlets describing the modulation heating system as installed in office buildings, together with test results from an investigation made of a modulation steam heating system.

AMERICAN BLOWER CO., Detroit, Mich. Bulletin No. 315, illustrating and describing "Ventura" disk ventilating fans. The bulletin contains a number of tables for ascertaining the capacities, speed, horsepower and sizes of fans.

NILES-BEMENT-POND CO., 111 Broadway, New York. Catalogue illustrating and describing heavy-duty lathes. The lathes included are from 24- to 72-inch swing. Gun lathes of from 53- to 108-inch swing are also described.

CUTLER-HAMMER MFG. CO., Milwaukee, Wis. Circular illustrating installations of the Thomas gas meter, illustrated and described in the March, 1911, number of MACHINERY. The circular also gives the results of tests made on the meter.

INTERNATIONAL ACHESON GRAPHITE CO., Niagara Falls, N. Y. Booklet entitled "Three Little Stories of Three Big Events and Three Winning Lubricants." The pamphlet refers to the use of oildag, gredag and aquadag as lubricants in gas engines.

PH. BONVILLAIN & E. RONCERAY, 9-11, Rue des Envierges, Paris, France. Catalogue No. 6, illustrating and describing a number of different sizes and types of molding machines built by the firm. The catalogue is published in the French language.

FRONTIER IRON WORKS, Cor. Grant & Letchworth Sts., Buffalo, N. Y. Blotter illustrating the large variety of gasoline motor cylinder castings which the company furnishes to builders of automobiles, aeroplanes and marine engines as a specialty.

ROCKWELL FURNACE CO., 26 Cortlandt St., New York. Bulletin No. 29, describing the Lalor automatic stop-valve designed to automatically stop the supply of oil in case of breakage of the oil lines or abnormal flow of oil to the burners in oil furnaces.

DETROIT TWIST DRILL CO., Detroit, Mich. Booklet No. 18 on Detroit carbon and high-speed drills, reamers, cutters, special drills, etc. The booklet contains lists and descriptions of a few of the standard types of tools, together with useful hints for operators.

WESTINGHOUSE ELECTRIC & MFG. CO., Pittsburg, Pa. Catalogue of Westinghouse controllers for railway shops. This catalogue was especially arranged and prepared for distribution at the Master Mechanics' and Master Car Builders' convention at Atlantic City, N. J.

HESS-BRIGHT MFG. CO., 21st and Fairmount Ave., Philadelphia, Pa. In order to facilitate the references to the data sheets issued by the company, a classified index has been arranged for them, and index separating cards, printed for the several classes, have been provided.